UNITED STATES DEPARTMENT OF AGRICULTURE

WORK AND EXPENDITURES OF THE AGRICULTURAL EXPERIMENT STATIONS, 1921

PREPARED BY THE
OFFICE OF EXPERIMENT STATIONS
STATES RELATIONS SERVICE

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A. C. TRUE, Director.

OFFICE OF EXPERIMENT STATIONS.

E. W. ALLEN, Chief.

RELATIONS WITH INSTITUTIONS FOR AGRICULTURAL RESEARCH.

Supervision of Work and Expenditures of the State Experiment Stations Under Federal Appropriations.

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Experiment Station Record.

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M

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
States Relations Service,
Washington, D. C., March, 1923.

Sir: I have the honor to transmit herewith a report on the work and expenditures of the agricultural experiment stations of the United States for the year ended June 30, 1921, in accordance with a provision of the act of Congress of March 4, 1915, entitled "An act making appropriations for the Department of Agriculture for the fiscal year ending June 30, 1916." (38 Stat. L., p. 1110.)

Very respectfully,

A. C. True, *Director.*

Hon. Henry C. Wallace,
Secretary of Agriculture.

CONTENTS.

	Page.
Position of the stations	1
Revenues of the stations	2
Projects carried on during 1921	5
Relation of projects to revenues	7
Changing character of station work	8
Some examples of intensive inquiry	9
Regional problems	11
Duplication in station work	13
Legislation affecting the stations	14
Changes in personnel	15
Whitman H. Jordan	15
Charles E. Thorne	16
Henry P. Armsby	16
Administrative and other changes	16
Additions to buildings and equipment	20
Station publications	22
Some results of station work	23
Botany and plant physiology	23
Genetics	27
Soils	29
Fertilizers	36
Field crops	39
Fruits	50
Vegetables	55
Diseases of plants	56
Entomology and zoology	69
Animal nutrition	77
Animal husbandry	82
Dairying and dairy farming	88
Veterinary medicine	94
Agricultural engineering	104
Sugar making	105
Rural economics	105
Insular experiment stations	106
Visitation of the stations	106
Statistics of the stations	107
General statistics, 1920–21	109
Revenue and additions to equipment, 1920–21	111
Expenditures from the Hatch fund, 1920–21	114
Expenditures from the Adams fund, 1920–21	116
Disbursements from the United States Treasury under the Hatch and Adams Acts from passage to 1921, inclusive	118
List of publications of the experiment stations during the fiscal year 1921	118

WORK AND EXPENDITURES OF THE AGRICULTURAL EXPERIMENT STATIONS, 1921.

By E. W. Allen, E. R. Flint, and J. I. Schulte.

The general condition of the agricultural experiment stations began to show some signs of improvement during the year. These were evident chiefly in a changed attitude toward the stations and an apparent realization of the crippled condition which had resulted during the war, with failure to respond to the needs following that period. There was a return of workers who had gone out into commercial enterprises, and a general stimulation of interest in the activities and the welfare of the stations.

While there was practically no increase in financial support in the aggregate, improvement was noticeable in individual cases, and in many others the stations were beginning to be relieved in various ways by their colleges which had benefited by increased appropriations. There was relief in the duties of teaching—if not a reduction in the number having such duties, at least a decrease in the amount required and a more advantageous scheduling of such duties. The colleges were able, through the relief they had received, to exercise a more liberal attitude in this and other respects. The station workers also profited by the increased salary scale entered upon by most institutions, which made the outlook for the future more attractive.

POSITION OF THE STATIONS.

One encouraging feature of the situation was a fuller realization on the part of administrative officers of the hard ways upon which the stations had fallen. For two years the addresses of the retiring presidents of the Association of Land-Grant Colleges have dealt pertinently with the importance of research and the necessity to the other branches of the college of making adequate provision for it. Chancellor Avery, of Nebraska, in the address of 1920, referring to the fact that instead of a return to normal the situation was even worse, declared that " if this condition is not remedied I feel that we are drifting toward sterile times in thought and progress. * * * Only by a radical change in our system can we hope to maintain that degree of efficiency in the work of investigation which till recently was the glory and pride of our colleges." He showed that the demand for such work was increasing, not only along the lines which had been followed in the past, but in many new directions which required the services of the investigator.

Dean H. L. Russell, in his presidential address in 1921, devoted his entire attention to the experiment station, with a vigorous discus-

sion of the difficulties confronting it and the inevitable effects. Calling attention to the changed emphasis in the colleges, following the inauguration of extension work, he said:

> Our farmers are by no means standing still in their agricultural processes. Constant advancement in extension work must be made to insure the highest degree of success. Unless research is constantly opening up new facts, new explanations, and new principles, extension teaching will soon sink to a sterile repetition of old material and die of dry-rot. Experimental inquiry is the living spring that vitalizes all other phases of agricultural instruction. If the fountain fails, all other activities languish.

The effects of diminished activity are not wholly immediate, as he well stated:

> They will show in the scientific results of the next decade. With the working power of the dollar at present reduced from a pre-war basis a third, if not more, and in comparison with the situation which obtained in 1906 even a still greater reduction, it is obvious that the experiment station is going backward rather than forward in its facilities, while on all sides greater and greater demands are being made on it for additional service.

These citations are sufficient to make it evident that not only the weakened condition but the key position of the stations in relation to future progress, and the broadening character of their field with the necessity that research become more fundamental, are realized by administrative officers, who are bending every effort to meet and correct the situation.

REVENUES OF THE STATIONS.

As in the past, the stations derived their main support from the Federal appropriations and those made by the States. In some cases the latter came in the form of specific appropriations for the use of the stations, while in others it was in the form of an allotment from the general appropriations for the agricultural college. Considerable amounts were frequently derived from the sale of products or from fees for inspection work, but rarely were these a source of net income for research.

The aggregate of the State appropriations for 1921 shows an increase of $192,556 over those for 1920, 24 stations reporting an increase, 18 a decrease, and 8 receiving the same appropriation as in 1920. Four of the stations (Ohio, Texas, Minnesota, and Wisconsin) received over $200,000, 11 stations received from $100,000 to $200,000, 13 from $50,000 to $100,000, 8 from $25,000 to $50,000, 4 from $10,000 to $25,000, 4 had less than $10,000, and 6 had no State aid. Fuller statistics on this and other points will be found in the tables at the end of the report.

The Alabama station received $6,875 from the State for the year and the local experiment fund of $27,000 was continued.

The State appropriations for the Arizona station for 1921 were about $50,000, including funds for a dairy barn, a greenhouse, and some minor buildings.

The Arkansas station received appropriations from the State of $43,074.67, of which $31,072.20 was specified for salaries and $12,002.47 for maintenance. An appropriation of $50,000 was made for the purchase of a tract of land at Scott, near Little Rock.

The California allotments to the station were $147,378.71 for general maintenance, salary, and experiment-station work at Berkeley, Davis, and all substations.

The State funds for the Colorado station for 1921 were $57,800 from the mill levy. In addition the legislature provided a special fund of $17,528.67, which includes $10,000 a year for the grading of perishable market produce and also a pure-seed appropriation of $12,000, available for testing and certifying seed.

The General Assembly of Connecticut increased the State appropriation for the State experiment station at New Haven from $45,000 to $82,000 for the biennium and provided a special appropriation of $10,000 for two years for research and experiments in the causes and prevention of diseases and injuries to the Connecticut tobacco crop, which occur in the field or in preparation for market, and for improving the crop by selection and breeding. With the cooperation of a growers' association a field station was opened and a specialist in tobacco diseases employed.

The Delaware State appropriation for the college farm and the station was increased from $10,000 to $20,000 per year beginning July 1, 1921.

The Florida station received only $5,000 from the State, but will benefit by an appropriation of $60,000 for the next biennium, out of which $10,000 a year was planned to be devoted to the Lake Alfred branch station.

In Idaho the total appropriation to the university for the biennium was $700,000, of which $57,308 was allotted to the experiment station for the biennium, which includes the substations.

The allotment of the Illinois station from the State funds for the year 1920–21 was estimated at $140,000.

The Indiana Legislature increased the State appropriation for the station, providing a levy of two-fifths of a cent on each $100 of taxable property, becoming available in July, 1922. It is expected that this will amount to about $234,600 for 1922–23. In the meantime an appropriation of $100,000 was given in addition to the $75,000 heretofore received. This appropriation is not made for specific purposes and permits large latitude.

The Iowa State appropriations for the station were $140,500, but a net increase of $30,000 per year has been made, of which it is specified that $25,000 shall be used for marketing and rural economics, and $5,000 for truck crops in southeastern Iowa.

The appropriations for the Kansas station included $55,000 for the central station at Manhattan, about $27,000 for the branch stations, and $5,000 for special investigations on contagious abortion.

The present State support of the Kentucky station is $50,000 a year.

The total appropriations for the Louisiana station is $50,000 per year, for the central station at Baton Rouge and the branch stations.

The Maine station received $15,000 support from the State for the year.

The Maryland station received about $54,000 from the State, practically the same as last year.

The total State appropriations for the Massachusetts station for the year were about $83,200.

The income of the Michigan station from the State was $197,013. It receives its support by allotment from a one-fifth-mill tax to the college.

The State support of the Minnesota station for the year was $219,000 with special appropriations of $5,000 for drainage work in cooperation with the Bureau of Public Roads, $5,000 for experiments in making sirup from sweet-corn stalks, and $3,000 for work on soils low in lime.

The income of the Mississippi station for the year from the State was $19,500 for the central station and $75,329.52 for the branch stations.

The State appropriations for the Missouri station for the year include $40,000 of which $10,000 was for soil experiment fields and $10,000 for soil survey. Additional appropriations were made to the college of agriculture as follows: For the new agricultural building, $200,000; a new cattle barn, $25,000; for fitting up a laboratory on the third floor of the horticultural building, $4,000; for repairs to the dairy building, $1,000; and repairs to barns $4,500.

The Montana station received $79,395.51 from the State for the year 1920–21, the amount being increased by the legislature of that year. On account of changing the end of the fiscal year from March 1 to July 1, an appropriation of $24,000 was made to cover the period. In the biennium 1921–1923 the central station will receive $98,700 for the first year and $100,000 for the second. For the branch stations, the Judith Basin substation receives $11,240 the first year and $12,000 the second, the horticultural substation $5,620 and $6,000, the Huntley substation $2,000 and $3,000, and the North Montana substation $19,540 and $20,000, respectively.

The allotment for the Nebraska station was about the same as last year, being $26,074, and for the substations $53,321.

The Nevada station is to receive $2,560 for the biennium.

The New Hampshire station has heretofore received no State support, but the legislature has now appropriated $5,000 for 1921–22 and $7,500 for 1922–23.

The New Jersey State station received $119,162 from State and other sources.

The income of the New Mexico station from the State for the year was $7,500.

The New York State station received an appropriation of $185,829 and the Cornell station an allotment of $192,630 from the college for research.

The North Carolina station had the use during the year of approximately $103,550 from funds of the State department of agriculture for experimental work, being divided into $37,000 for the branch stations, $3,000 for experimental work in agronomy, $8,000 for animal industry, $4,000 for general expenses, $45,000 for salaries, and the balance for minor purposes.

State appropriations for the North Dakota station totaled for the year $103,667.

The Ohio station received a State appropriation of $265,365 for the year.

In Oklahoma the college apportioned $10,500 to the station, an increase of $500 a year over the previous allotment.

The receipts of the Oregon station from State appropriations was $92,750 for the year.

In South Carolina the legislature appropriated $50,000 directly to the station, and it will no longer receive the allotment from Clemson College. This appropriation represents an increase of about two-thirds over the allotment it formerly received from the college. Half of this goes to the two branch stations and six cooperative test farms.

The South Dakota station reports an income of $14,460 from the State.

State appropriations for the Tennessee station amounted to $11,904.27. The west and middle Tennessee branch stations each received $10,000 from the State.

For the Texas station the State appropriations amounted to $220,520 for 1921, being quite specifically itemized.

The Utah station received for the year $53,469. The legislature voted an appropriation for the ensuing biennium of $115,000, in addition to $15,000 as a deficiency appropriation. The appropriations for the substations are included in the above.

The State appropriations for the Virginia station amounted to $38,350.

The Washington station received $87,760 from State appropriations to the college.

The West Virginia State appropriations for the year were $104,787.

The Wisconsin station does not receive a direct and separate appropriation, but derives its support from the appropriation made to the agricultural college. The net expenditures for research work for 1920–21, deducting receipts from sales, were not less than $210,000.

Several of the States made no appropriation for the stations, either directly or indirectly. Taking the revenues as reported above and in the statistical tables at the end of this report, the resources available to the individual stations are seen to vary very widely. While the support in some cases is liberal, in others it is so limited as to require operating on a very narrow margin. The rigid economy necessary at many of the stations largely determines the grade and efficiency of their work, for it affects the kind of investigators they can attract to their staffs and the facilities for study which they are able to provide.

PROJECTS CARRIED ON BY THE STATIONS DURING 1921.

The lines of work under investigation by the State experiment stations in 1921 show a total of 4,770 separate projects, an average of about 95 per station. Of this number 506, or an average of 10 per station, are conducted under the Adams fund, the support frequently being supplemented from other sources. Of the 4,770 projects 52 are administrative, control, or regulatory, leaving 4,718 projects dealing with experimentation and research. To these may be added 147 projects of the insular stations, giving a total of 4,865.

The classified list of these projects, owing to cross references and the fact that in some cases it is necessary to classify the same project under more than one head, contains a total of 5,489 entries.

The classification brings out the following facts as to the prevailing lines into which the station activities fall: Field crops lead with

1,535 projects, under which corn has 189, potatoes 126, wheat 119, rotations 95, cotton 85, oats 78, and alfalfa 71. Horticulture comes next with 808 projects, the principal groups being apples 102, fruits—general 64, vegetable and truck crops 46, grapes 43, tomatoes 39, peaches 38, and orchard management 36. Plant pathology follows with 419 projects, the largest groups being potato diseases 51, apple diseases 27, tomato diseases 26, and cereal diseases—general 23. Economic entomology has 395 projects, with bees 32, miscellaneous 27, insecticides 26, corn insects 16, and apple insects, codling moth, and flies 15 each. Under soils there are 284 projects, including soil fertility 55, soil types 32, soil flora 27, soil nitrogen 21, and soil moisture 20. The next largest subjects are veterinary medicine with 174 projects, rural economics with 172, rural engineering with 159, poultry with 152, and dairy cattle with 151. These are followed by fertilizers and swine, each having 141, botany 124, dairy products 118, feeding stuffs and animal nutrition 117, genetics 106, beef cattle 84, chemistry 82, forestry and sheep 68 each, foods and human nutrition 62, economic zoology 29, bacteriology 25, seeds 23, weeds 15, horses and mules 13, animal husbandry—general 11, agrotechny 7, and meteorology 6.

Grouping the projects broadly, agronomy subjects, including field crops, soils, and fertilizers, total 1,960 projects, or about one-third of the whole; botany and horticulture 932 projects, or about one-sixth; and animal husbandry, including dairying and dairy products, about one-eighth of the total; leaving about three-eighths of the projects on all other subjects.

The number of projects listed by the different stations varies widely, as would naturally be expected, considering the marked difference in revenue. Beyond this, however, the practice with respect to the detail in which the work is divided into projects varies widely, which in turn affects the scope and consequently the number of the projects. For the Federal funds the projects are fairly definite and restricted, but those supported by State funds are sometimes so elastic as to cover quite broad lines of work, rather than a specific investigation, thus tending to reduce the number reported by a station, even though its activities really cover a wide range.

The total number as reported for 1921 marks an increase of more than 500 projects over those reported as in progress in 1920. This is somewhat surprising, especially in view of the financial difficulties confronting most of the stations. Probably, however, too great significance should not be attached to a comparison based merely on an enumeration of project titles. Quite certainly one important factor has been the more complete adoption by the stations of the project system itself. Doubtless, too, the tendency toward greater definiteness in restating projects has resulted in a splitting up of numerous undertakings formerly described in more general terms, with a consequent increase in the total number, but without a corresponding extension of the work actually under way. In still other cases, the addition of new projects without a rigorous weeding out of others in a dormant state would swell the total number.

Each year the project system is becoming more firmly established and progress is being made in making it a catalog of definite research activities.

RELATION OF PROJECTS TO REVENUES.

The number of projects an experiment station is carrying does not express the entire need for investigation in the State, but the list may be taken to represent the best judgment of the station as to the most pressing questions which can be undertaken at the time with the resources at command. The fact that the average number of projects per station amounts to 95, as stated above, indicates the large number of questions which have been singled out as calling for attention and solution. This number of projects is probably too large for most stations unless they are strongly organized and supported, but it represents the attempt to respond to the demand as it is seen.

If the stations were at liberty to shape their project lists according to their resources, they might limit the number and raise the character of the attack on the relatively few which were concentrated upon. But for years they have felt the pressure for assistance in the way of new facts and reliable information, and the need is seen more keenly as time goes on. They attempt to meet the situation by covering as broad a field as their resources will permit, underestimating sometimes the necessary expense which will be involved and the provision which should be made for the projects to grow. It is hard for a station conscious of its duty to curtail its work and to effect economies. When once undertaken, it is not easy to drop a line of study, and its successful pursuit is likely to entail more and more expensive facilities, appliances, and procedure.

Some light may be thrown on the adequacy of the support by a consideration of the approximate cost of projects and the relation between resources and their number. Taking the total resources of the State stations at $7,660,570 as reported, and the total number of active projects for the year at 4,770, it is found that the average allowance per project is slightly more than $1,600. Of course, some projects are larger and some smaller, some are more expensive and some less so, but in the 48 States these variations tend to equalize one another sufficiently so that it may be warranted to speak of the average project and the average requirements.

The above amount is not considered excessive when the overhead and other charges, as well as the salaries of investigators, expense of field and laboratory work, clerical hire, publication of results, and the many other items of expense are included. It is the average of a variety of undertakings and a diversity of conditions. It is supported by the fact that at one station in the central West, which is conspicuous for its activity and the high grade of its work, and which keeps an accurate account of the funds used for investigation, the average amount expended per project was $1,650 during the year concerned. As that State has a wide range of projects, such as is called for in a typical agricultural region, and as its projects range from the usual field and feeding experiments to the more intensive types of investigation, its average may perhaps give a fair indication of the funds needed for a mixed program of successful investigation.

When the various States are considered, however, the amount available per project varies tremendously. It runs as low as $400 at one station, which is in the same general region as the one mentioned above; in others it is $1,000 to $1,200; in another group from $1,500

to $1,600, and in a considerable number from $2,000 to $2,500. Omitting extremes where the conditions are quite unusual, the general maximum is a little over $4,000, and occurs in States which have special substations involving relatively heavy expense compared with the number of projects listed. In other words, the provision made in certain States is ten times what it is in others for the annual support of an average problem selected on the best judgment of the station and its advisers.

It does not follow that the problems in one State are relatively less important for the welfare of agriculture than in another, or that the average problem in one locality is intrinsically more exacting, expensive, or worthy of solution than that of another. The data show, however, that the real situation is not equally realized in different States, or that some States are prepared to do less than others. Figured out on the above basis, the support is not found to be in accordance with the size of the State or the relative importance of agriculture in it. It gives a possible basis for expressing the requirements if the projects pressing for solution are to be adequately carried out.

CHANGING CHARACTER OF STATION WORK.

While there has been scant increase in funds for research, considerable improvement has been effected in strengthening the station activities and redirecting them into more progressive channels. The projects have been revised in many cases. There has been a concentration of lines of effort and the character of the inquiry has been made more intensive. There is a noticeable attempt to go behind the facts gathered in comparative trials and to get at their meaning and their competence or significance as a basis for generalization.

For many years there was a tendency to collect local facts quite largely, often with the attempt to give them a breadth of interpretation and application which it has since been found was not warranted. This is a danger in local experiments which do not take account of the real nature of conditions or make allowance for them in tracing the relation of cause and effect. The easiest form of experimenting is to collect local facts, giving to them merely a local interpretation or generalizing from such mass data. But the limitations of such types of experimenting have become evident, and, except for quite local and even temporary purposes, they fail to meet the requirements for sound information.

For this reason much attention is now being given to prescribing or determining the exact conditions of experiment and attempting to weigh individually the influence of the various factors which go to make up the complex situation found in nature and in practice. This calls for refinement of methods, and along with it provision of laboratory or other facilities which enable larger control. Practically every station now furnishes examples of such refinement of apparatus and appliances on a larger or smaller scale. They are becoming more common every year, and they are one of the reasons why present day experimenting and research are becoming increasingly expensive. The type of inquiry to which they apply attempts

to acquire basic facts, and the locality where these are determined is relatively unimportant in many cases, because, with the conditions and limitations known, these facts can be given their local application through relatively simple experiments.

Hence, without neglecting the problems of their locality, practically all the stations are contributing, in proportion to their ability, to the general advancement of knowledge applicable to an entire region or to the whole country. No station works to itself any more, or solely for its local community, and no station advances the lines in which it is interested purely by its own efforts. Each is a national asset, and this fact supplies one of the underlying reasons which justify national aid. Such aid is often applied to undertakings which are of interstate or regional importance, while local appropriations are frequently restricted in use and the provision of them is less responsive to this type of inquiry.

Gradually, therefore, the conditions are changing, both as to the types of activity and as to facilities for meeting the needs of station work. What once seemed luxurious and elaborate in such facilities has become more or less commonplace or accepted as essential in making further advance, and what formerly seemed extremely technical and highly specialized for so practical an institution as an experiment station, has come to lie in the very midst of its field. While the idea of what is practical in agricultural research has greatly broadened, the real purpose of such research has not been lost sight of, and the change from the field to the laboratory or to facilities of special construction has not had the effect of divorcing workers from interest in the practical aspects of agricultural problems. Rather, it is an expression of the nature of their quest and the desire to make the information they supply more complete and more reliable.

SOME EXAMPLES OF INTENSIVE INQUIRY.

As example of this more intensive inquiry it is only necessary to recall the studies in genetics, using small animals and noneconomic plants as well as those employed in agriculture; investigations of the nutritive requirements of plants, the toxic effect of combinations, the supply at different intervals of growth, conducted by means of water, sand, or other cultures; and the relation of light intensity and other physiological factors to plant growth. Furthermore, the studies of vitamins and other food accessories with rat colonies and other small animals, the extensive work on the composition and qualities of the proteins in various foods and feeding stuffs, the life history of groups of insects, the noneconomic along with the economic species, and the description and classification of such groups of fungi as the rusts, without restriction to those known to be harmful at the present time—these illustrate the breadth of inquiry designed to supply a broader basis of information and to better facilitate economic studies and deductions.

In soil studies dependence on field experiments has given way in part to elaborate systems of lysimeters and pits at several stations, with arrangements for studying seepage, fixation, balance of materials, and change of form. One institution has installed an extensive system of such lysimeters during the year, because its studies

had gradually enforced their need, and another has installed a battery of cylinders for studying the relations of fertilizing elements in the growth and functioning of apple trees. In some cases the installation of these special facilities has involved an initial expense of $10,000 to $15,000, and led to large operating expenses because of the nature of the work.

Highly complicated apparatus has been installed for maintaining desired temperatures of air and soil and bringing humidity under control, to aid in the quantitative determination of the physiological factors of plant growth; and similar provisions have been made for controlling environment in the study of plant diseases. The recent installation of apparatus in greenhouses at one of the stations to control air and soil temperatures at will, as a means of studying the reciprocal relations of plants and disease organisms with respect to environmental conditions, has involved an outlay of some $20,000, but has enabled work to be done having importance over wide sections of the country. These facilities mark a new point of view as well as new methods in the study of crop factors in health and disease.

The study of the flow of water and its accurate measurement, the principles of pumping machinery, etc., have necessitated the construction of hydraulic laboratories at a number of institutions far in advance of anything extant a few years ago. In animal feeding the facilities have not been confined to modern stables, spacious sheds, and paddocks for handling large numbers of animals, but special apparatus has been perfected for studying the metabolism of matter and energy, the physiology of food requirements and nutrition processes, and the basis of the theory of animal feeding. The employment of such apparatus has for several years been confined to the Institute of Animal Nutrition in cooperation with the Pennsylvania station, but of late a simplified form has been installed at the New Hampshire station through the assistance of the Carnegie Institution of Washington.

In the interest of investigations pertaining to special industries model working plants have been installed at several institutions. A fully equipped sugar house is maintained at one station for technical studies of the purification and handling of juices; specially equipped creameries and cheese factories have been provided for developing the principles on which the various phases of the art rests; and flour mills have been devised to determine the milling qualities of grains, with laboratories to study the causal relations between varieties, soil moisture, fertilization, etc., and the flour and bread making qualities. One such experimental mill, recently completed in Minnesota at a cost of $85,000, is said to be the most complete example of its kind in the world. At least one State has provided a special building and installed elaborate equipment, at a cost of fully $70,000, for studying experimentally the handling of fruit and fruit by-products, to determine the principles underlying the practical processes of manufacture; and another State is now erecting a large and specially equipped field laboratory for some of its horticultural investigations at a cost of more than $250,000.

The development of these and many similar enterprises, often on an extensive scale and quite highly specialized, evidences a departure

from a limited State view of problems. It expresses the idea of the mutual relationship and interdependence of experiment stations in pushing forward the boundaries of exact knowledge. Their effort in that field, especially in the advanced ranges, is a give-and-take process, in which any one of the participants may often receive quite as much as it gives.

REGIONAL PROBLEMS.

Each State has problems peculiar to its own local conditions, which arise from the types of farming pursued, the staple crops grown, as well as the physical conditions of climate, rainfall, elevation, etc. These conditions naturally vary more the farther States are removed from each other and as physical boundaries are passed which alter the character of the country, with the consequent variation in agricultural practices. There are, however, problems of a more general scope, which are bounded by sectional and regional peculiarities rather than by State lines, and a general review of the work in which the stations are engaged shows that emphasis is laid by whole groups of stations on problems arising from conditions peculiar to their section of the country.

Such larger sectional divisions naturally suggest themselves to one familiar with the country as a whole. There are, for instance, the coastal plains of the Southeast where cotton is one of the leading crops, the fruit sections of the Eastern States, the Corn Belt of the Middle States, the extensive dairy industries of the northern Middle States, the live-stock industries of the Great Plains, the arid regions of the Southwest, the fruit-growing industries of the Pacific coast, and the great Wheat Belt of the Northwest. These, of course, are not bounded by hard and fast lines, but run into and overlap each other extensively, and represent simply the leading feature of each part of the country.

Problems that are connected with such regional conditions lend themselves to cooperative work among the stations of the section, and this common interest in problems might cause the casual observer to think that there was more or less duplication in station work. This, however, is rarely the fact. The life history of an insect pest or a plant disease may vary to a considerable extent with a few degrees of latitude, and data that hold true in one State may be quite inapplicable in another. The same holds true as to varieties of crops best adapted to any region, which may vary with the difference of a few hundred feet of elevation or a few inches, more or less, of rainfall. A number of stations might, therefore, have project titles which to one unfamiliar with conditions might seem to be a duplication of the same work, but as a matter of fact are only apparent duplications made necessary by the different conditions under which the stations are working.

Briefly reviewing some of the more prominent problems of this nature, we find, for instance, in the southeastern stations extensive studies on cotton, including breeding experiments to develop a variety of good yield and suitable staple which will mature sufficiently early to escape or reduce the ravages of the boll weevil. As

a further aid in combating this pest, forage crops and animal industry problems are being studied in order to encourage a more diversified and self-sustaining farming system.

Among the serious diseases affecting cotton which are being studied cooperatively by the southern stations is anthracnose. Special efforts are being made to develop methods for its control, mainly by treating the seed and also by selecting resistant varieties. Most of the stations of this territory are studying the soft-pork problem to find ways of utilizing peanuts as a feed for swine and at the same time producing a firm pork, retaining the characteristic flavor generally prized by consumers in the Southern States which peanut feeding appears to impart. Experiments with the pecan, the peach, the various citrus and other orchard fruits, and with many of the vegetables that thrive in the region are carried on actively. The possibility of profitable expansion along some of these lines in many localities is realized, and the stations are accumulating data regarding the culture of these crops, better control of diseases and insect pests, and the handling and storing of the product. Other activities of the stations in these States include studies to prevent or minimize soil erosion, a serious problem especially throughout the Piedmont section.

Investigations of the experiment stations in the Southwest are largely concerned with problems of range management, dry farming, irrigation, and managing alkali soils. In the extreme South the growing of dates, citrus fruits, and other semitropical fruits is also being studied. Projects are now in progress dealing with the carrying capacity of the range, range improvement, effects of overgrazing, and efforts to combat poisonous plants of the range. The extent to which native desert plants may be used for maintenance of range live stock is being studied, and considerable work is being done to improve range cattle and sheep through the use of pure-bred sires.

Practically all of the stations in that section are engaged in the study of irrigation problems, particularly the available sources of irrigation water, composition of the water to be used, methods of distribution, and the extent to which land may be irrigated without detrimental results. Methods of growing crops in semiarid districts are under investigation, and work is being done to secure the adaptation of crops to dry-farming conditions. Studies of means for counteracting the alkali in soils and for its removal are in progress.

The potato leafhopper, sugar-beet leafhopper, cotton boll worm, grasshopper, and Mexican bean beetle are among the chief insect pests, the control of which stations in the Southwest are studying. Swamp fever of horses and the cattle tick present problems affecting the live-stock industry of the region, in addition to the more general diseases of animals which are under investigation. The adaptation of fruits and vegetables, field crops, forest trees, and ornamentals to the climate and various altitudes of the Southwest; the study of plant diseases, especially of grains and fruits, and methods of their control, as well as the development of immune varieties; and special problems in farm organization and rural economics are among the projects being carried on by the stations in this region.

The stations in the Northwest are naturally largely concerned with problems connected with wheat raising, which includes not only cultural practices, such as the value of summer fallow and rates and dates of planting, but also varieties and diseases and insect pests affecting this crop. The development of hardy fruits and forage crops by breeding and selection is a field that is covered by a number of the stations in this section and has resulted in the introduction of a number of valuable acquisitions. In those sections of the Northwest where corn will not mature the introduction of the sunflower as a silage crop is to a large extent due to the investigations of the experiment stations. In the great fruit section of the Pacific slope of the Northwest, problems relating to this branch of agriculture have received special attention, including such studies as orchard management and fertilization, storage, shipping, the utilization of by-products, the improvement of varieties grown by selection and breeding, and the control of diseases and insects to which they are subject.

In the northern Middle States the dairy industry is a prominent one, and it is perhaps the study of the feeding of dairy cattle and the production and nutritive value of milk and other dairy products that has led a number of these stations, as well as stations in the Northeast, to take up the subject of nutrition, which has in the past few years advanced to such an extent as to almost revolutionize previous theories, both as applied to animals and man. This is, of course, not a regional problem in itself, but its application is somewhat regional, as applied to the utilization of locally grown feeds, a subject that has engaged the attention of a large number of the stations.

Some problems, like hog cholera, contagious abortion, and tuberculosis, are not local or regional, but are applicable to the whole country, and in some cases are world-wide, and the study of such problems is naturally not confined to any particular group of stations.

DUPLICATION IN STATION WORK.

Fear is sometimes expressed that the experiment stations in different States are to a considerable extent duplicating their experiments and investigations. While there is repetition in different sections to test applications to local conditions, and while similar subjects are being studied by several stations to some extent, there is small ground for fear of duplication which is unnecessary and unprofitable. Especially is this the case where the inquiry is along advanced lines. The farther the work gets away from the commonplace the more individualistic it becomes in character. The danger of duplication lies chiefly in the stage where routine methods are being employed, with a purpose which does not reach beyond the local aspects.

The danger of duplication is small indeed in the advanced reaches of inquiry where the individual viewpoint and imagination are involved and where special apparatus and appliances have been evolved as tools in such inquiry. These things guard against duplication and tend toward concentration and specialization. As Chancellor Avery pointed out in his presidential address mentioned above, in

referring to the opportunity for closer cooperation and the carrying on at a relatively few places of special investigations applicable to the country at large, "there is an opportunity, in view of the demands made upon us, for a wise distribution among the several stations of some of the problems confronting us rather than that all should try to do everything in an inadequate way." This increase in specialization, and provision of the facilities required for it, is one of the most notable tendencies of the experiment stations and carries large promise for the future.

LEGISLATION AFFECTING THE STATIONS.

In Arizona appropriations were formerly made direct to the university and experiment station. The last legislature substituted a mill tax, which goes to the university as a whole. The station budget is made up by consultation of the director and dean and approved by the president and board of regents. A law was passed to pay the owners half the loss from animals dying under the tuberculin test, but no funds are available for this purpose. A law was also passed requiring all official seed testing to be done at the station.

In Indiana an act was passed levying a tax of two-fifths of a cent on each $100 of taxable property for the use of the experiment station, and until this becomes available $175,000 annually was appropriated.

The Michigan Legislature passed a bill creating the department of agriculture, to which was transferred all control work formerly handled by the agricultural college.

The Mississippi Legislature provided for establishing a new branch station at Raymond.

A measure was passed by the Montana Legislature providing that 1½ mills of the State levy of taxes should be for the maintenance of the university, also one providing for a bond issue by the State of $5,000,000, of which $3,750,000 should be used for building and equipment at the university. Of this amount $1,500,000 was available for the State college at Bozeman.

The Nebraska Legislature authorized the purchase of antihog-cholera serum for resale to farmers and farm bureaus, in lieu of operating the serum plant for that purpose. This dissolves an injunction in the court against the purchase and resale of the serum.

In New York a State employees' pension law, affecting workers at the State station, became effective January 1, 1921. This provides for voluntary retirement at 60 and compulsory retirement at 70 years. The amount of pension is determined by length of service and salary at time of retirement, but can in no case exceed half the salary at retirement.

Under an act of the Ohio Legislature, passed April 19, 1921, in which a general reorganization of the State government was provided, section 1172–2 of the General Code providing for the appointment of a board of control of five members was repealed, and the board of trustees of the Ohio State University and the State director of agriculture were constituted the board of control of the experiment station. The legislature also passed three bills relating to forestry, providing for a State forester and fire wardens and for the

prevention and suppression of forest fires, and making the chief of the department of forestry of the Ohio experiment station ex-officio State forester; providing for the establishment of a State forest nursery and enabling the creation of municipal, township, or county forests, and the levy of taxes therefor. Action taken by the board of control in January, 1919, uniting the departments of animal husbandry and nutrition in a new department of animal industry, which had been contested, went into effect in the spring of 1921, as a result of the courts in favor of the station administration.

The adoption of the administrative code by the Washington Legislature, consolidating the numerous boards, commissions, and offices of the State government into 10 executive departments, responsible to the governor, removed from the State college and experiment station the office of farm markets and discontinued the State board of agriculture, of which the director of the station was an ex-officio member.

CHANGES IN PERSONNEL.

At no time in the history of the experiment stations have changes come so rapidly in their administrative officers as in the past few years. From 1914 to 1920 the directorship of practically half the experiment stations changed. During 1921 ten more changes were added to the list, affecting the stations in Alabama, Florida, Maine, Minnesota, New York, Ohio, Oklahoma, Utah, West Virginia, and the Virgin Islands. The list was further extended by the death in the fall of 1921 of H. P. Armsby, director of the Institute of Animal Nutrition at the Pennsylvania State College.

This is an almost unprecedentedly long list for a single year and includes a number of directors who are conspicuous for the length and the character of their service. Four of these men had been associated with the experiment stations since their organization under the Hatch Act 34 years ago, and three were almost the last connecting links between the original State stations and the national system which grew out of them. Two others had been in the station work nearly or quite 30 years, while two more had served the stations for 14 and 17 years, respectively.

Whitman H. Jordan.—Doctor Jordan, who in June, 1921, retired from the directorship of the New York State station, which he had held since 1896, was one of the pioneers who aided in founding and building the American system of agricultural research. He was the first director of the Maine Fertilizer Control and Agricultural Experiment Station, established in March, 1885, and was called to the position from the professorship of agricultural chemistry in the Pennsylvania State College, where he had instituted a series of plat experiments. Doctor Jordan for many years was a great force in the upbuilding of the ideals and purposes of the American stations. From the first he exhibited a clear vision of the field and function of the experiment station as an institution for acquiring information through experiment and research. He was an active worker in the Association of American Agricultural Colleges and Experiment Stations and on many occasions set forth his high ideals for the stations, defining the essentials of research, pointing out tendencies he believed to be injurious, and presenting constructive suggestions.

His clear analysis of problems and the requirements for their solution was most helpful. He has a worthy successor at the station in Dr. R. W. Thatcher, formerly dean and director of the agricultural college and experiment station in Minnesota.

Charles E. Thorne.—Professor Thorne, who was relieved during the year of the directorship of the Ohio station at his urgent request, had served continuously in that capacity for 33 years. He had been associated with the movement for securing Federal support for an American system of stations, and had preserved the historical records of the successive attempts. Prior to the passage of the Hatch Act the Ohio station had received from the State about $5,000 annually. Under Professor Thorne's directorship the appropriation grew to approximately $300,000 a year, the largest for any of the stations. This remarkable growth is a product of the constructive planning and leadership of its director, supported by a confident and appreciative commonwealth.

Despite the heavy burden of administrative responsibility Professor Thorne had for years been actively associated with the station's investigation in the field of soil fertility, and he had for several years sought relief in retirement from the directorship in order that he might devote himself wholly to digesting and summarizing the results of this work. He is succeeded by C. G. Williams, agronomist of the station and for several years vice director.

Henry P. Armsby.—Doctor Armsby, director of the Pennsylvania Institute of Animal Nutrition, who died October 19, 1921, was the foremost exponent of research in the field of animal nutrition in this country and an international authority. For more than 40 years he had been closely identified with the work of the agricultural institutions. He entered the service of the Connecticut State station in 1877, two years after its establishment, and, except for an interval of two years in which he was vice president of the Storrs Agricultural School (now the Connecticut Agricultural College), he was continually in the service of the experiment stations up to the time of his death.

With the organization of the experiment station in Wisconsin in 1883 he became its chemist, and with the passage of the Hatch Act he was called to Pennsylvania to organize the experiment station in that State. He remained director of the station until 1907, when at his request he was relieved of the larger administrative duties of the station, and with the establishment of the Institute of Animal Nutrition, a product of his vision in that field, was enabled to concentrate his attention on this special line of inquiry.

Doctor Armsby was a wise and inspiring leader in the field of research, a faithful interpreter of the method and the results of science, and a man of very broad influence in the development of the purposes and the standards of the American experiment station.

Administrative and other changes.—Among others who relinquished directorships during the year, three deserve especially to be mentioned because of the long period of their service, namely: Charles D. Woods, for 25 years director of the Maine experiment station and previously chemist and vice director of the Connecteut Storrs Station from its organization in 1877; J. F. Duggar, whose service began as assistant director at the South Carolina station in

1890, and who was for 18 years director of the Alabama station; and P. H. Rolfs, who, with two short interruptions, has been associated with the station work since 1891, and director of the Florida station for 15 years. These men were conspicuous in their respective fields, and the stations over which they presided owe much to them for wise development and administration. They were succeeded by Dan T. Gray as director of the Alabama station, Wilmon Newell at the Florida station, and W. J. Morse at the Maine station.

H. G. Knight, who withdrew as director of the Oklahoma station, was succeeded by C. T. Dowell. F. S. Harris, director of the Utah station, left to accept the larger administrative position of the presidency of Brigham Young University, being succeeded by William Peterson. J. L. Coulter, dean and director in West Virginia since 1915, left to become president of the agricultural college in North Dakota. W. C. Coffey, of the Illinois college and station, succeeded R. W. Thatcher as dean and director at the Minnesota college and station July 1, 1921.

In this connection mention should be made of the passing of C. H. Fernald, a pioneer in the field of economic entomology, and associated with the work in Maine and Massachusetts from 1871 until his retirement in 1910. Doctor Fernald was for many years entomologist at the Massachusetts experiment station, and as a teacher trained an unusual number of men who have attained eminence in economic entomology. He died February 22, 1921, at the age of 83 years.

In addition to these administrative changes there was a long list of resignations or changes in the heads of important departments of the stations.

Resignations at the Alabama station included A. F. Thiel, head of the plant pathology department; J. C. Price, associate horticulturist; and G. S. Templeton, head of the animal husbandry department, the latter being succeeded by J. C. Grimes.

At the California station resignations included J. E. Coit in citriculture and D. T. Mason in forestry; and appointments included R. F. Miller, professor of animal husbandry; C. A. Phillips, associate in dairy husbandry; B. A. Rudolph, research associate in plant pathology; and W. E. Tomson, associate in animal husbandry. S. Lockett was appointed associate in veterinary medicine and resigned during the year.

At the Delaware station J. M. LeCato, associate plant pathologist, resigned and was succeeded by J. F. Adams. Changes at the Florida station included the appointment of O. F. Burger in charge of the plant pathology department, succeeding H. E. Stevens and C. D. Sherbakoff. R. P. Bledsoe was appointed agronomist at the Georgia station, to succeed T. S. Buie, resigned. At the Idaho station G. R. McDole was appointed associate agronomist, giving primary attention to soils, and H. P. Davis, head of the dairy department, resigned to accept a similar position at Nebraska College and station. In Indiana O. G. Lloyd was appointed chief of the department of farm management; H. W. Gregory, chief of the department of dairy husbandry, succeeding O. E. Reed, who resigned; J. J. Davis became chief of the new entomology department; and T. M. Bushnell was made associate in soil survey.

The changes at the Iowa station involved mainly assistants, but included also the resignation of H. B. Munger as chief of the farm management section, and the appointment of C. L. Holmes as assistant chief of the agricultural economics and farm management section, and of F. F. Sherwood as assistant chief of the dairy section. At the Kansas station L. F. Payne was appointed associate in poultry husbandry; B. M. Anderson, assistant, succeeded E. F. Ferrin as associate in animal husbandry; R. J. Barnett was appointed pomologist; and R. M. Green succeeded F. L. Thomsen as associate in agricultural economics.

The more important changes at the Louisiana station included the appointment of J. F. Brewster as research chemist and the return of W. L. Owen as bacteriologist at the sugar station at New Orleans. T. H. Jones was appointed entomologist to the station, and G. Dikmans, as assistant in veterinary medicine, in charge of the department of parasitology.

In addition to the change in directorship at the Maine station, noted above, J. W. Gowen was appointed biologist to succeed Raymond Pearl. At the Massachusetts station G. H. Chapman, research professor in botany, resigned to accept a position in the tobacco work under the Connecticut State station. The only change of importance reported from the Michigan station was the appointment of O. E. Reed as head of the dairy department. W. H. Peters was appointed acting animal husbandman at the Minnesota station, to fill the vacancy caused by the resignation of C. W. Gay, who became head of the department of animal husbandry at Ohio State University.

D. J. Griswold resigned as animal husbandman of the Mississippi station and was succeeded by C. J. Goodell. Other additions to the staff included E. Brintnall, dairy department; J. C. C. Price, horticultural department; D. C. Neal, plant pathology department; J. N. Lipscomb, farm management; and E. P. Clayton, poultry department. R. R. Hudelson was appointed associate in soils at the Missouri station and resigned during the year. J. C. Wooley was appointed head of the agricultural engineering department; and R. M. Green resigned as associate in farm management. At the Montana station, the agronomist, P. V. Cardon, resigned, being succeeded by Clyde McKee.

Changes at the Nebraska station included the resignation of J. H. Gain, associate in animal diseases; J. H. Frandsen, head of the dairy department; and J. W. Calvin, associate in agricultural chemistry. H. P. Davis was appointed head of the dairy department and J. C. Russel, formerly assistant in agronomy, was made associate in soils.

There were an unusual number of changes at the New Mexico station. J. G. Griffith, head of the biology department, resigned and was succeeded by R. Middlebrook; R. L. Stewart, station agronomist, resigned, and C. A. Thompson succeeded him as acting agronomist, but resigned during the year; G. R. Quesenberry was transferred from the department of farm management to fill the position of agronomist; R. B. Thompson, head of the poultry department, was succeeded by F. E. Uhl; and the resignation of V. F. Payne, nutrition chemist, was met by the appointment of L. S. Brown.

Changes at the New York Cornell station included the appointment of D. B. Carrick in the pomology department, and the resignations of E. G. Montgomery, head of the department of farm crops, K. C.

Livermore, of the farm management department, and E. O. Fippen in soil technology.

At the North Carolina station F. E. Miller succeeded R. W. Collett as assistant director of branch stations; B. F. Brown was appointed chief of the division of markets, succeeding W. R. Camp, resigned; D. T. Gray, head of the animal husbandry department, resigned to accept the directorship of the Alabama station; W. A. Withers, who had been chemist at the station for many years, was assigned wholly to college duties; and H. M. Lynde, drainage engineer, died during the year.

At the North Dakota station R. F. Beard, cereal chemist, resigned and was succeeded by C. E. Mangels. C. D. Grinnells resigned from the animal husbandry department and was succeeded by J. W. Haw, who later in the year resigned and was succeeded by D. J. Griswold. A new department of entomology was added to the station and R. L. Webster appointed as its head.

At the Ohio station, following the resignation of the director, C. E. Thorne, C. G. Williams served as acting director during the remainder of the year, being later appointed director. Professor Thorne continues his connection with the station as chief of the department of soil fertility. W. J. Green resigned as chief of the department of horticulture and was appointed consulting horticulturist. J. H. Gourley was appointed chief of the department. E. B. Forbes, chief of the animal-industry department, resigned, being later succeeded by Gustav Bohstedt, and D. C. Kennard was appointed associate in the department.

Among the changes at the Oregon station is noted the appointment of R. C. Jones as associate dairy husbandman and a few changes among the assistants.

At the Rhode Island station H. G. May was appointed to succeed P. B. Hadley as chief in animal breeding and pathology and P. S. Burgess was appointed associate in agricultural chemistry.

At the South Dakota station A. T. Evans succeeded M. Champlin as associate in agronomy.

The changes in the staff at the Tennessee station included the appointment of C. D. Sherbakoff, of the Florida station, as pathologist, and S. Marcovitch as entomologist to succeed G. M. Bentley.

The Utah station lost by death G. B. Hendricks, in charge of the marketing work, and W. L. Wanlass was appointed to fill the position. W. W. Henderson resigned as entomologist. G. A. Olson resigned as head of the division of chemistry in the Washington station, and was succeeded as acting head by J. L. St. John.

Appointments at the West Virginia station included E. P. Deatrick as associate soil technologist, R. J. Garber associate agronomist, and J. H. Gourley as horticulturist to succeed J. K. Shaw, resigned. R. M. Salter resigned as head of agronomy and soils. At the Wyoming station E. H. Lehnert resigned as head of the veterinary department and Cecil Elder was appointed acting head. F. A. Hays was appointed associate animal husbandman.

These changes in personnel were in part due to personal preference and advantage, and in part to an upbuilding and strengthening of the station staffs. In a number of instances specialists who went out into commercial positions returned to continue their sta-

tion activities. Salaries were made somewhat more attractive, and the relation and position of the station and its staff within the institution were more definitely recognized. Conditions as a whole became more stable despite the many changes, and the opportunities offered for a career in the stations presented a more encouraging outlook.

ADDITIONS TO BUILDINGS AND EQUIPMENT.

Changes in the physical plant have been on a rather limited scale, owing to the paucity of funds and to high prices. In a number of cases the stations have shared or are to share in new buildings erected for the general use of the colleges, and in others the acquisition of land by the colleges has added to the facilities for experimentation.

In a number of instances the need for expansion is becoming quite urgent. At several of the stations the question of securing farm land adjacent or convenient to the station is becoming a serious one, owing to the growth of the communities in which they are located. Outlying farms located at a considerable distance have been acquired to some extent, but these have the disadvantages of being time-consuming to visit and not having the close oversight which experimental work usually requires.

The agricultural building of the Alabama Polytechnic Institute, which housed a large part of the station activities, was unfortunately destroyed by fire during the year. A considerable portion of the equipment of the departments of administration, agronomy, soils, plant pathology, botany, entomology, horticulture, and animal husbandry was lost. The loss of the records in these departments seriously interrupted the work of the station, involving the field notes and data secured through many years, which can not be replaced. This emphasizes the necessity of keeping such records in fireproof vaults, and also the advantage of duplicate records.

At the Arizona station a dwelling for the foreman at the Salt River Valley Farm was completed. On the university campus a new milking barn was completed during the year, and also a greenhouse with 1,500 square feet under glass. A seed-testing apparatus valued at $600 was secured.

The California Legislature provided $400,500 for buildings and improvements at the university farm at Davis. These will be erected during the coming biennium, the two principal buildings to be one for the activities of the dairy department, including a plant for the manufacture of butter and ice cream and the pasteurization and distribution of market milk, and a building to house the division of pomology, viticulture, and botany.

At the Connecticut State station a field of 13½ acres of tobacco land was purchased with the Lockwood trust fund for experimental work on tobacco.

The creamery at the Georgia station was enlarged and supplied with equipment including separators, churns, and aerators.

The Illinois Legislature appropriated $500,000 for the first unit of a new agricultural group. This will be devoted almost exclusively to instructional purposes, but it is the beginning of a new plant which will serve the experiment station as well as the college. The legis-

lature also appropriated $260,000 for a horticultural field laboratory, which is nearing completion.

At the Indiana station a new horse and cattle barn and a poultry house were constructed at the Moses Fell Annex at Bedford. An extension was added to the dairy barn at the university, accommodating 20 cows.

The Iowa station reports the purchase of a farm of 176.6 acres for the animal husbandry section. This adjoins the college lands on the Lincoln Highway. An experimental sunlit community hog house will be built, and a complete cattle and sheep experimental barn with paddocks is being planned to meet the future developments of the animal husbandry experiments.

In Mississippi a residence was built at the Delta substation for the assistant director, costing $10,000, at the Holly Springs and South Mississippi branch stations potato-curing houses were added, and at the new substation at Raymond a dwelling, barn, and minor buildings were erected.

The remodeling of the horticultural and botany buildings at the Minnesota college, at a cost of $90,000, afforded additional laboratory facilities for station work in horticulture and plant physiology and pathology.

In Missouri the State appropriated $150,000 for a new agricultural building, which will provide offices and research laboratories for investigation. The department of soils and rural life, the agricultural library, and the dean's office will be located in this building. A new cattle barn was also provided for, to cost $18,750.

Additions to the equipment of the Nebraska station included the installation of thermographs and temperature boxes for the study of bacterial diseases, and equipment for the agricultural engineering buildings.

The Nevada station reports the addition of a sheep shed with equipment including feeding racks, watering troughs, etc., for lambing and feeding tests. One and a half miles of dog proof woven and barbed wire fence was built on the station farm.

Work was begun on a new building for the department of dairy industry at Cornell University, and the contract was let for a new agricultural building in North Dakota. A beef-cattle barn was constructed at the coast station, South Carolina, at a cost of about $2,000.

The University of Tennessee completed and dedicated an imposing agricultural building, located at the university farm and adjacent to the extensive field work of the experiment station. A large part of the building, especially its laboratories, was specially designed for the use of the experiment station and with respect to its needs. The station headquarters, library, and major departments are brought together in this building.

At the Utah station a new plant industry building was completed, costing about $150,000. An irrigation laboratory was installed in the agricultural engineering building, to cost about $1,200, in which the station has a half interest. A tract of 17 acres adjoining the Greenville farm was purchased for $7,125, and a horticultural farm of 20 acres along the interurban railway between Ogden and Salt Lake City was secured. Permanent equipment to the value of $5,400 was added to the station.

Additions to the West Virginia University and station included a new barn at the horticultural farm, costing $10,000, and two large egg-laying houses, costing $1,800 each, and a new brooder house, costing $1,000, at the poultry farm. The old dairy barn was repaired at a cost of $2,800. On the animal-husbandry farm a completely equipped hog barn was constructed, costing, with new equipment, $5,500. On the agronomy farm, $7,500 was expended for concrete foundations, a new pumping system, and repairs.

STATION PUBLICATIONS.

There was a revival of activity during the year in the publication of results of experiment station work. For several years the publications had been lagging behind because of the cost of printing and the condition of the station funds. Many technical papers were prepared for publication in scientific journals, as has been the practice of late. These dealt with aspects of investigation which were of special interest to students of the subject, the practical results and their application being issued in the station series. Of late there has been much attention to the systematizing of these outside publications, sometimes bringing them into a regularly numbered series and otherwise arranging for the securing of separates to make up library sets and for exchange purposes.

There has been a decline in the voluminous annual reports formerly issued, and instead a brief administrative report with a record of progress on the projects and the chief events of the year has become common. Several stations have given special effort to preparing a report in popular form, summarizing for the public the chief results attained and giving reports on the progress of other projects, together with matter of general interest. These reports have had the effect of popularizing the station work and bringing it home to the general reader. In addition, more attention has been given to press reports of the station activities and results, employing in some cases the avenues of publicity opened up by the agricultural extension work. These efforts have been well worth while, for the public deserves to be kept informed promptly on matters of interest, and, on the other hand, the station deserves to have its hearing before the people. So much of the work is now of a technical character, owing to the nature of the problems presented for study, that it needs to be explained and interpreted in order that its practical bearings may be understood and appreciated.

A bibliographic help which is worthy of special note was prepared by Miss M. Helen Keith, of the Illinois station, and issued by the National Research Council, under the title "Bibliography of Investigations Bearing on the Composition and Nutritive Value of Corn and Corn Products." It occupies nearly 200 manuscript pages and contains over 1,200 separate entries. It is designed primarily to aid investigators and research students in the nutritional side of the corn-feeding question.

An attempt is made for the first time to classify in this report the principal station publications of the year. Omitting press bulletins and others of more transient nature, the list includes 75 annual or biennial reports of the stations, substations, and other

features, 23 periodical bulletins, and 51 bulletins relating to inspection or regulatory work. Of the regular bulletins, 52 related to soils and fertilizers, 76 to field crops of various kinds, and 52 to horticultural subjects.

There were 46 bulletins dealing with diseases of plants, 46 with entomology, and 17 with veterinary medicine, while 66 were devoted to animal production and 37 to dairying and dairy farming. Agricultural engineering had 15 bulletins, and rural economics, a relatively new subject, had 41. In addition there were quite a number of bulletins under such general heads as agricultural chemistry, botany, meteorology, human nutrition, and miscellaneous.

The classified list of these publications is given at the conclusion of this report (p. 118).

SOME RESULTS OF STATION WORK.

Following is a condensed summary of the more outstanding results of the work of the stations for the year. Conditions have been quite favorable for investigational work, and good progress has been made in many important lines of study. While many of the problems are of such a nature that they may extend over a series of years, others are of shorter duration, giving results perhaps in a single season. Some of the more fundamental problems in agriculture engage the attention of most of the stations, others having more local application.

BOTANY AND PLANT PHYSIOLOGY.

Plant nutrition.

Experiments at the Indiana station show that aluminum and ferrous iron ions are very injurious to plant growth, and that it is necessary to maintain conditions in the soil which will keep them unavailable to the plant. Their effect on the plant is the production of streaking and intervascular tissue necrosis of the leaves, and a discoloration and disintegration of the vascular plate tissues in the nodes of the stalk. This can be corrected by adding soluble phosphates to the soil. At the New Mexico station it was found that iron may be present in sufficient quantities in the soil surrounding plants affected with chlorosis, but its utilization may be hindered by some other soil constituent.

The New Jersey station reports that a slow current of air passed through media, either solution or sand cultures, almost doubled the yields of crop as compared with those obtained from untreated cultures. Cultures for soy beans, which produced high yields of either tops or roots, were characterized by high percentages of calcium nitrate and were correspondingly low in magnesium sulphate, these two compounds apparently being the determining factors in the yield, monopotassium phosphate having less influence. The highest yields were obtained from sand cultures in which the solutions were continually renewed by a constant drip of the nutrient solution, thus affording aeration. The quantity and form of air needed for maximum plant production in nutrient media are determined by a number of different factors, including the H-ion concentration, concentration of soluble phosphates, and other salts forming precipitates with iron, volume of the medium employed, the number of plants

in a given volume of medium, and the nature of the light, more iron being required during periods of sunshine and less during cloudy periods. Chlorotic conditions and low yields resulted from cultures in which ferric phosphate was the only source of iron, this being correlated with high Ph values. This form of iron, however, was readily available in solutions containing ammonium sulphate, and in such, high yields were associated with relatively low Ph values.

The California station finds that temperature is a very important factor affecting the growth efficiency of nutrient solutions. Those high in phosphorus or magnesium were not as good culture media for wheat seedlings at relatively high temperatures as at relatively low ones. Solutions high in calcium nitrate showed a better growth efficiency at high than at low temperatures. Wheat grown in water cultures showed a direct stimulation of growth when the concentration of sodium chlorid was about 5,000 parts per million, but when this reached 14,500 parts per million the plants died. There was no effect at very low concentrations. Small amounts of manure added to pots containing sodium chlorid, carbonate, and acid carbonate, had a marked preventive action on the toxicity of these salts to growing barley.

The Montana station finds that arsenic in the soil disturbs the normal function of plants, but its effects soon disappear, due largely it is thought, to the development of tolerance.

Studies at the Delaware station show that toxic effects and permeability may be altered by the use of compounds giving identical ions but in a changing ratio of anion to cation in different mixtures. The specific effects of any given salt do not seem to depend wholly upon the fact that the metallic (positive) element of the compound is monovalent or divalent, or that it may be an alkaline earth or an alkali metal, but is the resultant of the individual effects of each ion itself upon permeability.

The New Jersey station finds that nitrogen in the stems of plants is directly related to fruit production, a low nitrogen content of the stem being always correlated with high fruit production, and vice versa. This correlation was not shown in the leaves or roots, indicating that the nitrogen translocated to the developing fruits is largely drawn from the main stems of the plants.

It is noted at the Kentucky station that in the utilization of the reserve material in the cotyledons, in the growth of beans, a smaller proportion of calcium than of phosphorus or magnesium is translocated.

At the Delaware station indications are found that the several enzymatic processes do not keep step with the increase of the vegetative activity of the plant, but that the enzymatic response to the addition of the compounds used as fertilizers is markedly specific and affects the various enzymatic activities differently. These processes have been utilized to form a new basis for the selection and breeding of corn, by which means it was possible to produce highly inbred strains that equalled cross-bred corn in vigor.

Isolated cornroot tips were successfully grown in sterile nutrient solutions, at the Missouri station, if glucose was present. In Pfeffer's solution, containing 2 per cent of glucose, cornroot tips made a lim-

ited growth in the dark, which was increased in the light. The addition of peptone or autolyzed yeast improved the growth. In a mineral nutrient solution containing glucose, mineral salts, and autolyzed yeast, isolated cornroots were maintained for more than 12 weeks in the light.

Studies on sap concentration at the California station show that the sap is most diluted when new shoots are just beginning to form and most concentrated when they are in a dormant condition. Pruning tends to reduce the concentration.

Moisture relations of plants.

Studies in transpiration, mainly with corn, at the Nebraska station, showed that this varied, per gram of dry matter, from 192 to 445 grams in two extreme years. The results show that transpiration is directly dependent on weather and leaf area, and is proportional to evaporation from a free-water surface. High evaporation and transpiration are reflected in low yields. The transpiring leaf is somewhat cooler than the atmosphere in the hottest part of the day, but a dry leaf without water to transpire becomes hotter than the air. Little encouragement was found for the selection of strains on the basis of low transpiration, but more for selection on a basis of dry matter. A wide difference was found between plants and varieties in water requirement, smaller varieties and those with smaller leaves taking less water, although the proportion to dry matter was practically the same. Some crops, like sunflowers, are extravagant users of water as compared with corn.

The Nebraska station finds that the adaptation of corn to regions of low rainfall consists chiefly in the reduction of vegetable development and consequent reduction in the amount of water used by the individual plant, and this factor rather than lower transpiration per unit of dry matter produced accounts for the variation in water requirements of different varieties. The amount of water used per pound of dry matter varies very little regardless of the native source or acclimatization of the seed. The use and economy of water differ greatly in different years, following roughly the evaporation from a free-water surface during the principal growing period of the plants. Comparing results from fertile and infertile soils, the latter produces smaller plants which use less water per plant but not more per pound of dry matter. An increase in soil fertility reduces the transpiration (dry matter ratio) until the optimum fertility for plant growth is reached. The remedy for lack of water is not found to be an increase in soil fertility.

The Minnesota station found that awns on wheat are very important from the standpoint of transpiration, this being twice as great where awns are present as where they are absent. This may have some correlation with the larger grains of awned wheat.

Effects of light.

Investigations at the New Hampshire station show that the intensity of sunlight or the amount of solar radiation received by plants has a marked effect on type of growth and size, structure, and color of their leaves, their roots, and upon their reproductive processes as indicated by flowering. The leaf area was increased by shading, sometimes as much as 200 per cent. The thickness of the

leaves was greatly reduced in some cases, in the apple nearly 100 per cent, the modification involving particularly the palisade cells and mesophyll. Moderate shading intensified the green color of the foliage, and the leaves dropped several days earlier than the checks. The root systems were materially reduced by growth in the shade. In herbaceous plants, flowering was reduced and sometimes entirely suppressed, and it was reduced and delayed in fruit trees.

At the Massachusetts station oats were grown under different amounts of light. When grown from seed from plants in which the intensity had been reduced about 30 per cent, a more vigorous germination and a stronger plant resulted. Plants exposed to ultra-violet light from the mercury vapor lamp, in addition to daylight, gave considerably more vigorous growth, which, however, was more brittle. By screening out all ultra-violet rays there was a more vigorous growth of seedlings, up to a certain point only. In the radish where the rays were not sifted out the roots have a red color, but where these rays were eliminated the roots were white. In general, the long ultra-violet rays were found to be injurious, coagulating the albumin and injuring the cells rapidly.

Seed studies.

Seed studies at the New Jersey station show that differences in weights have a very pronounced influence upon germination, subsequent development of the plants, time of flowering, production of fruit, and time of fruit maturity. A marked difference was found in the absorption of water by the seeds of different species. Legume seeds showed a higher rate of absorption than others. Among those treated, alfalfa showed the highest and corn the lowest. The absorption rates decreased with increase in the osmotic concentration, except in dilute solutions.

A quick method of determining the germinating ability of seed, requiring only a few minutes, based on the peroxidase reaction with guaiacum, has been devised by the Kentucky station.

Effect of manganese.

The results of an investigation at the Kentucky station show that when manganese is added to an acid soil toxicity is developed. Using radishes as a crop, while the tops did not show much effect, the roots were much diminished by the presence of manganese in an acid soil, and where the manganese reached 50 parts per million in the soil extract the plants would not grow. In a neutral soil the growth was better and toxicity did not show until 100 parts per million was reached. Peas grown in water cultures with no manganese began to deteriorate after a normal growth for four or five weeks, the young buds dying back. The seeds contained a small amount of manganese to begin with, which was evidently sufficient for the first stages of growth. Plants receiving manganese made a normal growth. Carried to blooming, they gave a higher dry weight. Plants receiving a solution of 8 to 10 parts of manganese per million began to show toxic effects, but up to 4 to 6 parts they made a normal growth. Soy beans, cowpeas, and corn were grown with similar results, those receiving traces of manganese giving markedly higher green and dry weights. The results show that from 0.1 to 1 per cent of manganese in the soil is beneficial, but more than this causes diminution of the crops. Legumes seem to require this element more than nonlegumes.

The Alabama station finds that sorghum will stand considerably more manganese than clover.

Effect of soil temperature.

At the Wisconsin station a difference is found in the composition of wheat grown at different soil temperatures, the carbohydrates in the stem and leaves being higher when grown at lower temperatures. With corn, the results were not as conclusive, but there was more hemicellulose at higher soil temperatures. Corn was also found to be more resistant to root rot organisms at higher temperatures, differing from wheat in this respect.

GENETICS.

Determination of characters.

Data secured at the New York Cornell station show that there are one or more modifying factors concerned in the development of the red color of cabbage.

The Oklahoma station in working with sheep find indications that early lambing is an individual and not a racial trait. The absence of horns is found to be dominant to their presence.

Studies at the Connecticut Storrs station show that the difference between high, mediocre, and low producing hens depends on two dominant factors, one sex-linked, and the other autosomal. Absence of both determines low fecundity, the presence of either, mediocre, and the presence of both, high fecundity.

At the Massachusetts station broodiness is found not to be a single Mendelian dominant. The male is a large factor in its transmission. There are evidently two factors involved in broodiness.

At the Wisconsin station the various stages of "blueing," the replacing of black by blue in the plumage of pigeons, appear to depend on separate, definite, independently heritable factors, whose expression is such that each one higher in the series (producing more black) covers the effect of all those below.

At the Kansas station 10 characters have been located in studies on the grouse locust (*Apotettix eurycephalus*) with such definiteness that a chromosome map may be made. Twelve forms with three different combinations have been produced in which individuals breed true. Twenty or more generations have been secured with a very distinct mutant of Paratettix.

Correlation of characters.

A study of the correlation of characters in corn at the Virgina station showed that the later the plant flowered the lower the yield. The correlation between the yield and length and width of leaf is low, but there is 63 per cent correlation with the size of stalk and 75 per cent with the weight of stalk. The correlation of ear characters and weight of grain was high, except with that of tapering ear, in which it was only 50 per cent.

Cotton studies at the Texas station indicate a correlation of oil content with lint characters and protein, but not with total yield.

Work with oats at the Alabama station showed a close correlation between height of plant and yield, the latter being heavier with the taller plants.

Resistance to stem rust in oats is found at the Minnesota station to be a simple Mendelian dominant and easy to transmit to the third generation.

A study of the correlation of characters in the peanut, at the Alabama station, showed this to be low in the percentage of meats to the weight, also in length of stem to percentage and weight of nuts and meats. A high correlation was found between the number of branches and weight of meat, and the weight of meat to the weight of nuts in the shell. No correlation was found between the length of stem and total weight of vegetative parts or the percentage of meats to the number of single pod nuts.

Linkage of characters.

Studies at the New York Cornell station on the relative intensity of linkage in pollen and ovule development indicate that there is little difference in the frequency of crossing over in mega- and microsporogenesis in maize. It was also found that the intensity of the linkage of factors, in at least one linkage group in corn-teosinte hybrids, is markedly different from that in pure corn, while in others the strength of linkage is practically the same as in pure corn.

At the South Carolina station barrenness in corn is found to be a hereditary factor linked with purple color. The stalks of barren corn are larger and the plants heavier and stockier. A rather high percentage of barrenness is found in common corn, from 5 to 12 per cent in most fields, this being on the female side only, normal tassels being produced. It can be reduced by detasselling the barren stalks before the tassels develop.

The study of inheritance of spangling in poultry at the Missouri station shows this to be controlled by a sex-linked factor. Hen feathering in the males of the Seabright bantams is transmitted through both sexes by a single dominant factor, which is not sex-linked. A cytological study of the testes of male and female feathered cocks gave no evidence that male feathering is due to an internal secretion from the so-called lutear cells of the testes.

Crossing.

A method of inbreeding corn has been devised by the Connecticut State station that is being extensively used. It involves the bringing together each year of inbred strains, the progeny of each pair being the parents of the improved strain. Four stock inbred strains must be carried and the crossing repeated each year. It is giving excellent results.

Strains of cotton selfed for nine years at the North Carolina station show no lack of vigor, and the F_1 hybrids do not show exceptional vigor, which is contrary to what has been observed in case of corn. The natural crossing of cotton is found to be 4 to 6 per cent only. As this plant has 52 to 54 chromosomes, there is a chance to combine several characters. Strains have been obtained that for 7 years have varied in averages from 985 to 2,061 pounds per acre of seed cotton and from three-fourths to $1\frac{1}{8}$ inch staple.

In work with wheat at the New York Cornell station it was found that, while neither Polonicum nor Kubanka are pubescent, the F_1 plants are pubescent and in the F_2 hybrids various types of pubescent forms are obtained. On the long-glumed types no pubescence is found.

The Maine station has shown that milk yield and butter fat percentage are definitely transmitted by both sire and dam to the first generation crosses of dairy and beef breeds. High milk production is partially dominant to low and low butter fat percentage to high.

SOILS.

Soil fertility.

Studies in soil fertility at the North Carolina station showed that Norfolk fine sandy loam is decidedly more responsive to fertilizers than Cecil sandy loam or Toxaway loam. Corn was a more efficient crop than wheat on both the latter types of soils. A closer relation was found between chemical analysis and field experiments with reference to plant food deficiencies in the Piedmont region than in the Coastal Plains, potash being more important and phosphoric acid less so in the latter than chemical analysis indicates. In the black-land soils profitable crops can not be grown without the use of lime. Fertilizing without lime depressed the yield, and the application of 3 tons of lime per acre did sweeten the soil to a depth of 8 inches. Contrary to the general belief and practice, the use of lime was found to greatly increase the yield of tobacco, when grown on bright tobacco soil, without apparently affecting deleteriously the quality and selling price, and also contrary to the long accepted idea on this same soil the use of muriate of potash produced a greater yield of tobacco than sulphate of potash without apparently injuring the market quality.

At the Kentucky station on certain types of soil which were nearly neutral, rock phosphate gave as good results as acid phosphate. Experiments at the Texas station showed a closer relationship between the active phosphoric acid of the soil and the results obtained with pot experiments than in the case of the total phosphoric acid. At the Ohio station the addition of basic material (lime) enabled more phosphoric acid to be taken up from an acid soil.

Results at the latter station showed the fixing capacity of soils for potash to be greater where they had not received this element than where it had been applied. Limed soils were found to have a greater capacity for fixing potash than unlimed.

At the Utah station wheat plowed under when 6 inches high, 12 inches high, in early bloom, and in the milk stage, showed decided reductions in yield in a succeeding crop of wheat as the different stages advanced for plowing.

At the Rhode Island station, where corn was grown continuously with a complete fertilizer containing 20 pounds of nitrogen per acre and with a legume cover crop plowed in, a yield of 84 bushels of corn was obtained. Sixty pounds of nitrogen with a rye cover crop gave 70 bushels, and with no cover crop, 55 bushels.

Soil acidity and liming.

Extensive studies have been conducted on soil acidity and its correction by liming. The Alabama station finds that applications of sulphate of ammonia result in a pronounced increase in soil acidity.

A survey of the soils of the State by the Pennsylvania station showed that 72 per cent are in need of lime and that on only 15 per cent of unlimed soils can a good crop of clover be grown. The lime requirements of soils which had never been limed varied from 1,749 to

3,105 pounds per acre. Well-drained soils were found to be less acid than poorly-drained ones and the lime requirements were found to bear a close relationship to productivity.

Tests by the Oregon station showed that the red hill group of soils have the highest acidity, while the well-drained soils in the valley floor and recent stream and river bottoms had only slight or moderate acidity.

At the Rhode Island station the complete neutralization of all acidity by lime reduced the oat crop more than half. Chlorosis was noted in oats and other crops when the soil was completely neutralized, indicating that it is undesirable to lime so persistently that the soil will not impart a slightly pinkish color to blue litmus paper. A slight acidity seems to be favorable to the growth of plants. Data were secured which indicate that the effect of acid phosphate and lime in correcting acidity is probably due, in part at least, to precipitation of active aluminum by these substances. Similar results were observed at the Indiana station, which reports the acid phosphate instead of increasing acidity decreased it by precipitating the soluble aluminum salts. The Illinois station, however, finds no evidence that aluminum is a cause of acidity.

The Wisconsin station finds that corn is able to withstand more acidity than soy beans. Studies at the New Jersey station indicate that it is not profitable to try to grow the common legume crops, such as alfalfa, vetch, clover, soy beans, etc., on soils having a Ph value lower than about 6.5. In plats of different lawn grasses, at the Rhode Island station, soil acidity was maintained to such an extent by the application of sulphate of ammonia in place of nitrate of soda, that weeds were entirely eliminated.

The best soils, according to results obtained in pot experiments at the Kentucky station, have the highest total calcium content, and vice versa. Cultivation results in the loss of calcium. Calcium treatment caused an increase of ash and calcium content in the plant, regardless of any increase in growth.

The Tennessee station finds that heavy applications of lime remain largely as oxid or hydrate, changing only slowly to the carbonate. The effect of heavy applications on the mechanical condition of the soil is marked.

Experiments at the Iowa station show that gypsum has no effect on soil acidity, but seems to have some effect in making potassium available and stimulates certain bacterial activities. It does not, however, replace lime.

The Missouri station notes that the poorer soils give greater returns from the use of available phosphates than from lime, and it is believed that, with the present prices and freight rates, liming on such soils should only be done after the yields have been brought up as far as possible by the use of phosphates, barnyard manure, and rotations including legumes.

Indications from experiments at the New York State station are that both calcium and magnesium limestones, in amounts far below the calcium requirements of the soil, will produce normal yields, especially of alfalfa. In some cases small applications have given more satisfactory results than large ones.

An examination of 50 soils at the Iowa station showed no correlation between the lime requirements and the H-ion concentration. A

sandy loam with a low lime requirement may have a much higher H-ion concentration than a silt loam with a much greater lime requirement. An acid soil low in organic matter showed a higher H-ion concentration than one of the same lime requirements having a high content of organic matter.

The Oklahoma station reports that after five years lime had penetrated through 2 feet of hardpan on Kirkland subsoil. Kafir and alfalfa roots had penetrated the hardpan from 2 to 2½ feet where lime or manure had been added, but not where these were omitted. At the Oregon station an increase of ammonification followed the application of up to 4 tons of lime per acre, and nitrification increased in proportion to the amount of lime added up to that limit. Lime promoted aeration and fixation of nitric acid and favored nitrogen fixation by Azotobacter.

The Rhode Island station reports that the residual effects of crops, which may be marked, appear to be dependent upon the reduction of bases (lime) and increase in acidity. The effects were much more uniform and less pronounced where the plats were limed.

In a liming test at the Alabama station corn and cotton were practically ruined, but no other crop was injured. The Tennessee station states that the occasional injury to crops by liming may be explained by the increased amount of nitrogen which the lime carries off, thus delaying maturity.

Soil alkalinity.

Experiments at the California station indicate that a small amount of barnyard manure has a marked preventive action on the toxic effects of relatively large quantities of soil alkalis. The resistance of wheat to sodium chlorid was found to be extremely high, and concentrations up to 6,000 parts per million showed distinct stimulation in growth, although a peculiar temporary depression occurred at the lower concentrations, which is effective both for roots and tops at certain stages of growth. Contrary to previous opinion, barley was found to be very tolerant of alkali. With calcium chlorid, sodium sulphate, and sodium chlorid in equal osmotic concentrations, calcium chlorid is the most toxic, sodium sulphate next, and sodium chlorid least. Where soils are not too alkaline, applications of sulphur were found to neutralize alkalinity.

A study by the station of the causes of the formation of alkali showed that it may be due, among others, to the leaching of granitic rocks, the interaction between chlorids and calcium carbonate, and the action of chlorids on silicates. When hydrolyzed and subjected to the carbon dioxid of the air these appear to form the black alkali. Larger amounts of gypsum than have usually been recommended are found to be necessary for the reclamation of alkali land.

The Massachusetts station reports that calcium sulphate depresses alkalinity, but not to the point of acidity, and that it also depresses the solubility of calcium carbonate. Muriate of potash, on the other hand, usually forms sodium chlorid in the soil, which has an opposite effect to that of calcium sulphate on alkalinity and the solubility of calcium carbonate. The Utah station finds the presence of organic matter to be an important factor in the toxicity of alkali. At the Arizona station, Sonora wheat was found to be much more resistant to black alkali than barley. The Oregon station concludes

that irrigation and drainage for removal of alkali by flooding, with open ditches 10 feet deep, followed by treatment with sulphur, gypsum, ammonium sulphate, manure, or straw will bring under cultivation much greasewood or sagebrush land in the State that is now practically worthless.

Soil bacteria.

Examination by the Kansas station of a large number of soils from that and other States showed that only about 12 per cent of those that had not been limed contained Azotobacter. These soils gave a reaction favorable to the growth of Azotobacter; that is, H-ion concentration of the solution of less than 1×10^{-6}. Some limed soils also contained none of these organisms. The minimum concentration for these was found to be about Ph_6. They were readily established in acid soils after neutralizing with calcium or magnesium carbonate and disappeared from limed soils as they became acid again.

Experiments at the New Jersey station indicate that growing plants have a beneficial influence upon oxidation activities in the substrata in which the plants grow and suggest a symbiotic relationship between the soil oxidizing organisms and growing green plants.

Studies at the Oregon station indicate that a little sulphur, especially in combination with lime, stimulates nitrification, maximum development of nitrates being obtained with the use of lime and sulphur. At the Colorado station, sulphur applied at the rate of 2,500 pounds per acre retarded both nitrogen fixation and nitrification. Straw decreases nitrification, as shown by results at the Illinois station, and results in loss of nitrogen.

Investigations by the Montana station showed that considerable nitrate was formed in alkali soils, especially those high in organic matter. An accumulation of nitrate was found in almost all kinds of rocks, due, it is believed, to oxidation of organic nitrogen. It is also found on the surface of old brick and mortar, cement, and building stones, supposedly due to fixation. The Colorado station has also made extensive studies on the occurrence of nitrates on the surface and inside of rock masses.

The Utah station has studied bacterial activity in dry land and in irrigated, manured, and unmanured soils, ranging from a loose sand to a very tight clay, and in soils devoid of and very rich in organic matter. Every soil gave a maximum ammonification when it contained 60 per cent of its water-holding capacity of moisture. Nitrification was at its maximum at about 65 per cent of moisture. Most of the soils showed two maxima for nitrogen fixation, one at 50 to 60 per cent and one at 70 to 80 per cent. The addition of alkalis to the soil changed the figures somewhat. The New York State station reports that Actinomycetes are more active under so-called toxic conditions than in normal soils.

At the Missouri station, soils that were well supplied with *Bacillus radicicola* were treated in various ways. Samples were left out of doors but protected from contamination. Others were dried in the sunlight and some in the dark, and later stored so as to be protected from contamination. After three years the sun-dried samples still had enough viable bacteria to produce good infection.

The Idaho station finds that accumulation of ammonia and nitrate is distinctly retarded by applications of sawdust, needles, cones, bark, and other tree products. The greatest retardation resulted from the application of cedar sawdust and needles, maple products being next in order of toxicity. The reduction of ammonia and nitrate accumulation ranged from 5 to 60 per cent. Nitrogen fixation was greatly decreased by some of the products and practically eliminated by others. These investigations indicate the cause of the low productivity of forest soils.

In a study, at the Alabama station, of soil toxins, of all the organisms isolated from 30 soil samples, 80 per cent were found to decompose vanillin and 20 out of 27 decomposed cinnamic acid. Salicylic aldehyde was found to be unavailable as a source of carbon to the organisms. A few were found that would decompose hydroquinone. Bacteria will not grow in caffein, but molds do.

Nitrification.

Studies at the Ohio station show that nitrification can not take place until some of the cells of the organism are broken down to give the initial energy to start the process. By the addition of hydrogen peroxid to ammonium sulphate the formation of nitrate is secured without the presence of organisms, supposedly by a change analogous to nitrification. The breaking down of cells appears to supply a product which corresponds in its action to the hydrogen peroxid in the chemical reaction.

At the Washington station it was found that straw applied to the soil stimulates reproduction of bacteria, but there is no disturbance in the balance of types present. The bacteria use the straw as a source of carbon and the nitrates in the soil as a source of nitrogen, transforming this into organic nitrogenous material unavailable for plant food. The more straw applied the greater is the loss of nitrates.

At the Washington station 12 to 15 per cent of moisture in the first foot was found to give the best conditions for nitrification.

Extensive studies on soil nitrogen at the Missouri station show that nitrate production is increased both in manured and unmanured soils by the addition of limestone. The rate of nitrate production on corn plats, both manured and unmanured, is low as compared with the timothy plats. The results of three years' study show that the growing crop is of much significance in the removal of nitrates, the accumulation being reciprocal to the rate of crop growth; that spring plowing increases nitrate accumulation, but a 3-inch surface tillage lessens the amount of nitrates in the upper 7 inches; and that a heavy straw mulch depresses nitrate production decidedly.

The New Jersey station reports that nitrates were found in considerable quantities in soil samples which showed the highest H-ion concentration, indicating that nitrification is not necessarily inhibited by a highly acid condition of the soil.

Nitrogen fixation.

The Kansas station finds that aeration is a determining factor in the development of Azotobacter. Protein synthesized by Azotobacter supplied with various sugars was found to act much like water-soluble B vitamin in case of animals, indicating that the organisms may be capable of producing this vitamin. The Ohio station found

Azotobacter capable of utilizing combined nitrogen and that only after this was exhausted did fixation of free nitrogen take place. The presence of Azotobacter, therefore, does not prove that free nitrogen fixation is taking place, as the organism will follow the line of least resistance. The California station reports that the fixation of nitrogen is proportional to the amount of energy consumed.

The Colorado station reports nitrogen fixation as taking place on sandstones, cultures being made from a number of samples from widely separated localities. A number of bacteria were found, but associated action apparently did not increase the activity of the nitrogen-fixing organism. It is believed that they derive their energy from rock-infesting lichens. Traces of nitrates were found in many rocks, lichens in these cases also evidently furnishing the energy required for the bacterial activity.

Five years' results of lysimeter experiments at the New York State station show an accumulation of from six to seven times as much nitrogen under alfalfa rotation as under timothy.

Loss of nitrogen.

Studies at the Tennessee station have demonstrated the accelerative tendencies of all forms of lime and magnesium, in small or moderate amounts, upon the outgo of nitrogen by leaching. They also show decided inhibition induced by excessive amounts of calcium and magnesium oxids and the recovery from the partial sterilization, as a parallel to reversion of the oxids to the carbonate forms. The initial tendency of the subsoil to stop the downward movement of nitrates is shown, together with the pronounced later tendency of the accumulation of the alkali-earth bases in the subsoil to cause either a yielding of the nitrates held there or else a generation of nitrates from the nitrogen stores contained in the subsoils.

The Texas station finds a close relationship between the nitrates produced in the soil and the amount taken up by plants in pot experiments, and that the amount of nitrates removed by the crop is reflected in a decrease of nitrates in the soil.

The New York Cornell station reports that the reduction of nitrates is especially active in soils under timothy and that bacterial activity is greater in cropped than in bare soils. Analysis of the drainage water from lysimeters at the New York State station, extending over five years with a Volusia soil, has shown that under a four-year rotation, including two years of alfalfa, the soil lost over seven times as much nitrate nitrogen as did the same soil under a rotation in which timothy replaced the alfalfa. In spite of this greater loss of nitrate from the soil under an alfalfa rotation, this soil has given in the barley crop succeeding alfalfa an increase of 4,370 pounds per acre over barley after timothy. The Kansas station finds it possible to maintain the soil nitrogen but not to increase it by growing alfalfa.

Effects of straw.

The Washington station shows that the nitrogen-carbon ratio in organic material returned to the soil has a very pronounced influence on the kind and rate of decomposition. Organic materials like straw, having a wide nitrogen-carbon ratio (1 to 75) produce a depressing effect on the nitrate development, and this effect is felt until there

has been sufficient decomposition to cause this ratio to approach that of the organic matter in the soil (1 to 13). Before this stage of decomposition is reached nearly all of the carbon is lost as carbon dioxid, and consequently residues, like straw, can not be depended upon to materially influence the soil organic matter. When organic matter having a narrow nitrogen-carbon ratio (1 to 10), as in the case of legumes, is incorporated in the soil, there is an immediate and rapid nitrate development with little loss of carbon dioxid and indication of greater organic matter maintenance. The resulting high nitrate content, following the plowing in of a legume, frequently causes lodging or "burning" of the succeeding grain crop. When straw is spread on the legume before plowing in this difficulty is largely overcome. Nitrogenous fertilizer, when applied with straw, was effective in overcoming the decrease in yields of small grain, so commonly experienced when these are grown after straw has been applied alone.

Burning all the straw on the land at the Utah station gave yields of about 2 bushels of wheat less than where the straw was plowed under.

Soil sulphur.

From investigation at the Tennessee station as to whether the oxidation of soil sulphur was wholly chemical or partly due to bacterial action, it was found that sterilized soils still showed oxidation. Liming affects the outgo of sulphur as well as of nitrogen, the sulphur being lost as calcium and magnesium sulphate, none as sulphid. Considerable sulphur is brought down from the atmosphere, in some cases as much as 100 pounds per acre per year. Sulphur oxidation in the soil parallels nitrification. Most of the soil sulphur is in combination with calcium, some with magnesium, and a little with iron.

The New Jersey station has isolated two sulphur oxidizing organisms, one acting in an acid soil, the other in an alkaline soil.

Tillage.

In tillage tests at the Wisconsin station deep plowing and subsoiling were not found profitable, deep tilling tests giving the lowest yields. The Texas station also finds that the presence or absence of weed growth is of more importance than the exact nature of the soil mulch maintained by cultivation. In experimental plowings of 3, 6, 9, and 12 inches, 6 inches or less was the most economical. At the North Dakota station it was found that in dry years soils subjected to a great amount of cultivation do not appear to retain their moisture as effectively as land where less cultivation is practiced. At the Oregon station it is shown that summer tillage of fallow accumulates nitrates and conserves moisture.

Soil erosion.

Erosion experiments at the Missouri station showed that land plowed 4 inches deep in the spring and fallowed during the remainder of the year lost over 1 inch of the surface by erosion, land in corn lost 0.5 inch, and land in sod only 0.01 inch. Based on the amount of eroded material under the conditions of the experiment, 7 inches of surface soil would be eroded in 25 years on the plat that

was shallow-plowed and cultivated, in 50 years on continuous corn, and in 2,300 years in sod. The nitrogen loss was excessive in eroded soils.

Miscellaneous soil studies.

The West Virginia station reports that soil can be sterilized by pressure, but shows considerable variation due to water content, results being best when a fair amount is present. The H-ion concentration is not changed by this treatment. The method has been applied with success to potatoes for use as a medium on which to grow the late blight of tomatoes. Butter can be sterilized by this method, but its keeping qualities are injured somewhat.

In lysimeter work at the Tennessee station, shallow rims, 12 inches in height, were better than deep lysimeters for soil work, as the subsoil in deep tanks fixes the elements so that they do not appear in the drainage water.

The Utah station finds that a clear soil extract may be obtained by adding either lime, ferric sulphate, ferric alum, or sodium or potassium alum to the soil-water mixture and then filtering through a Chamberland-Pasteur filter or centrifuging. The last three give a clear solution with a minimum amount of salt. Lime, ferric sulphate, or ferric alum cause a considerable loss of nitrates. For the determination of chlorids and nitrates, five minutes is sufficient to agitate the soil with water, if the soil is finely divided, but a longer time is required if sulphates are to be determined, depending on the kind and amount present.

FERTILIZERS.

Phosphates.

Tests at the Illinois station show that if too great an excess of lime is applied with rock phosphate it has an adverse influence on the facility with which the phosphate becomes available. Large amounts of rock phosphate gave as good results at the South Carolina station as small amounts of acid phosphate. Good results were obtained with Tennessee blue rock.

In studies at the Georgia station of composting rock phosphates with organic ammoniates, a maximum availability of 3 per cent was obtained in six to eight weeks. Five months composting of cottonseed meal and rock phosphate resulted in a loss of 60 to 70 per cent of the total ammonia. Of the total dry matter in the compost mixture, the loss was from 25 to 35 per cent, but where a small amount of sulphate of ammonia was added only 8 per cent of the total dry matter disappeared, while 60 per cent of the total ammonia was lost. The amount of total phosphate made available varied from 7 to 20 per cent. When acid phosphate was applied with substances such as calcium carbonate or ferrous sulphate, which are capable of reverting it, higher yields were obtained in the second year than from applications of acid phosphate alone.

Studies have been carried on at the New Jersey station on the possibility of converting rock phosphates into an available form by means of sulphur oxidation.

At the Alabama station heavy applications of acid phosphate on very acid soils gave a phenomenal growth of sorghum, but there was

an entire failure of clover following this. Plats in wheat at the Missouri station gave increased yields of 6.2 bushels with calcined phosphate, 4.9 bushels with basic slag, 2.7 bushels with steamed bone meal, 2.3 bushels with acid phosphate, and 2.4 bushels with rock phosphate.

The Wisconsin station finds that sweet clover feeds strongly on raw rock phosphate and feldspar, while buckwheat does not make use of the latter. Sweet clover has a neutral or nearly neutral sap, while that of buckwheat is unusually acid, although it does not give off strongly acid excreta.

Sulphur as a fertilizer.

At the New Jersey station plats receiving 1,000 to 4,000 pounds of sulphur per acre gave a considerable decrease in the yield of barley, and the yield of soy beans following barley decreased sharply from 700 to 30 or 40 pounds per acre in plats receiving 4,000 pounds of sulphur.

At the Oregon station sulphur was found to cause greater nitrogen assimilation by legumes through the beneficial effect on nodule development, and the amount of sulphur taken up by the plant was limited by the total nitrogen absorbed. It was shown that the presence of nitrates influences the amount of sulphur taken up by the plant to form compounds containing nitrogen and sulphur. Rape, however, will take more sulphur than is needed for this synthesis, depositing the surplus as sulphate in the ash. An application of 100 pounds of sulphur every four years on alfalfa increased the yield over a ton per acre. While it seemed to supply a real deficiency, its most important effect was aiding nitrification by stimulating nitrifying bacteria. White, alsike, and red clover also responded well, while results with field peas and beans were less definite. Oats seemed to require a moderate amount.

At the Washington station elemental sulphur gave increased yields of wheat, oats, barley, and peas, and a striking increase in the yield of alfalfa was secured with gypsum. The sulphur content of Washington soils was found to be insufficient, especially for legumes. While gypsum produced no increase when applied to small grains, when used on legumes it not only increased the yield but produced a hay of higher nitrogen content. This would indicate that it acts more as a stimulant than as a plant food. Tests at the Texas station showed that the soils of that State have little or no need for additional sulphur, ordinary fertilizers usually containing sufficient.

Available iron.

Investigations at the New Jersey station show that ferrous sulphate is the most available and efficient form of inorganic iron in preventing chlorotic effects in plants grown in nutrient solutions, but became very toxic in media in which the H-ion concentration was maintained at a high level by the plant. In such media, ferric phosphate was found to be the most efficient source of iron.

Borax injury.

Tests with borax at the North Carolina station showed that as little as 1 pound of anhydrous borax per acre injured tobacco and no cotton would grow in pots of sandy soils containing it at the rate of

5 pounds per acre. In clay soils both corn and cotton showed marked injury when the amount of borax exceeded 7 pounds of anhydrous borax per acre, but the plants survived. Borax disappeared from the zone occupied by the roots with sufficient leaching. The New Hampshire station finds that borax is most liable to be harmful if applied in drills below the seed. Beans and corn were more susceptible than potatoes. Three pounds of anhydrous borax per acre was the greatest amount that could be applied with safety, in drills, to beans. The limit for corn was somewhat under 5 pounds and for potatoes slightly over 5 pounds. Lime, gypsum, or manure prevented some of the injury.

Preservation of barnyard manure.

At the New York State station acid phosphate was found to be the most efficient agent for preserving manure, among many substances tried. It not only held more of the nitrogen but also appeared to conserve the organic matter of the manure. Peat was also quite efficient, but soil, gypsum, and rock phosphate were of much less value. Straw greatly reduced the fertilizing value of manure.

Green manuring.

Studies in green manuring at the Virginia station showed that the younger the green crop turned under the better was the growth and color of the wheat grown. When the green manure crop (clover) was cut off and removed a yield of corn of 35.28 bushels was secured, but when it was turned under the yield was 40.5 bushels, with 17.76 bushels on the check plats with no green manure. With rye as the green crop, the yield on the cut-off plats, was 17.03 bushels of corn and on the turned-under plats 23.66 bushels. Using soy beans as the green crop and growing wheat, the yield on the cut-off plat was 21.97 bushels, and on the turned-under plat 26.94 bushels, with 17.33 bushels on the check plat. With buckwheat as the green crop, growing wheat, the cut-off plat yielded 13.64 bushels and the turned plat 16.66 bushels.

At the Mississippi station forest leaves, straw, pine needles, corn stalks, cotton stalks, alfalfa, and stable manure were turned under to get the cumulative effect, growing oats as an indicator. The forest leaves, corn stalks, and pine needles did not show any effect the first year, but a marked one the second year. A test of the amount of green manure that can profitably be turned under indicated that 40 tons of alfalfa to the acre gave the maximum results, being a little higher than where 60 tons were turned under. When the soil was limed, however, 60 tons gave the higher yield, indicating that one factor causing the decrease with that amount was acidity.

At the New York Cornell station, using as measurements the rapidity of humus formation, the accumulation of nitrates, and the increased availability of the plant nutrients, the subsequent plant growth indicated that the greatest rapidity of decomposition and the greatest benefits to the soil were secured by the use of green manures at the half-grown stage, this being true of the three crops tried—rye, oats, and buckwheat.

Miscellaneous.

It was shown at the New Jersey station that with fertilizer constituents well balanced for good growth and with approximately

optimum conditions of soil moisture, a medium or even a low fertilizer application has greater plant-producing value than a heavier application with the soil moisture conditions either above or below the optimum for plant growth.

Availability studies at this station have made it clear that it is not necessary for the farmer to pay more for nitrogen in the form of organic materials than in the form of nitrates.

FIELD CROPS.

Crop improvement.

The Oklahoma station has produced a selected strain of Kingfisher barley that has yielded at the rate of 54 bushels per acre, as compared with 35 bushels of the original variety.

Corn-breeding experiments at the Minnesota station indicate that high protein varieties can not be obtained which also have maximum yielding ability. The Nebraska station has found second generation hybrids in pure lines to be less productive than first generations, and that close relationship between pollen and silks is undesirable. Seed from first generation hybrids gave somewhat higher yields than the original corn.

At the Iowa station a strain of Reid's Yellow Dent has been developed to which the name Iodent has been given. In the State corn-yield contest this new variety stood seventh among 48 samples from the south-central section of the State. At the station it matures from 6 to 10 days earlier than the average Reid's Yellow Dent and promises to be of importance in certain sections of the State.

Six promising strains have been developed at the Connecticut Storrs station, in cooperation with the State station, which are being distributed. Early plantings gave the highest yield of dry matter. Results of inbreeding carried on for 16 years at the Connecticut State station show that this does not necessarily result in weakened strains and is a valuable means of plant improvement. The method used, devised by this station, involves the bringing together each year of four inbred strains, carrying the four stock strains, with the repetition of the crossing each year, since the corn grown from the double-crossed seed has no particular value for further planting.

The New York Cornell station has developed three promising strains, Cornell 11 and 12 and Webber's Early Dent. No relation was found to exist between score-card points, yields, and earliness. Early maturing Dents gave the largest quantities per acre and appeared best for silage.

In experiments with corn at the Mississippi station but little gains in yield were secured by crossing the varieties commonly grown. In one case an increase of seven bushels per acre was secured, but it often resulted in reduced yields. Most of the varieties themselves are hybrids.

In cotton-breeding experiments at the Mississippi station, while Mendelian numbers were not obtained with many characters, in crosses, they were obtained with lint, leaf color, and smooth or fuzzy seeds. Considerable success has resulted from the breeding and selection work, and some seed has been distributed that has yielded 1½ bales per acre. An improved strain of Belton developed by the Texas station is being widely grown in some sections of the State.

In cotton-selection studies at the Arkansas station, "lint frequency," or "lint index" (the amount of lint on 100 seeds), rather than percentage of lint, is considered the proper basis to work from to increase the yield. It was found possible to increase the lint percentage, while the size of seed and length of lint were appreciably lowered.

Selection of cotton at the Alabama station has given an increased percentage of lint, but also susceptibility to anthracnose. A number of improved strains have been distributed and are being widely planted. A variety which is quite wilt-resistant is now almost exclusively grown in some sections. A comparison of the yield from light and heavy seed gave 742 pounds per acre for the latter and 600 pounds for the former, the checks yielding 636 pounds.

In acclimatization tests with cotton at the Mississippi station, in cooperation with the North Carolina and Texas stations, Mississippi grown seed produced slightly earlier, taller, and higher yielding plants.

Studies with flax at the Minnesota station have resulted in the production of high-yielding strains, combined with rust resistance. The North Dakota station has successfully crossed disease-resistant strains on nonresistant strains, retaining the good qualities of the latter.

The Iowa station has developed a high-yielding pure line pedigreed variety of oats to which the name "Iowar" has been given. This has yielded 8.8 bushels more per acre than other varieties with which it has been compared. The Kansas station has also developed a new variety which has given yields of 10 bushels over other varieties and has been named "Kansas Fulghum." Remarkably fine results have been reported by farmers with Idamine oats, developed at the Idaho station.

Selection of oats for higher yields at the Alabama station has been successful and improved strains are being distributed. Some hybrids have been secured which show considerable rust resistance. One strain is showing up well for hay, but the yield of grain is low.

Selected, treated, and certified strains of potato seed at the Wyoming station yielded 290 bushels per acre, compared with half that from commercial strains. At the Utah station the 1921 crop gave 156 bushels per acre of unselected, as compared with an average of 260.8 bushels for all selected strains, one of which yielded as high as 532 bushels per acre. Parent stock known to be diseased reproduced disease in 65 per cent of the progeny hills, as compared with 16 per cent for the progeny of undiseased parent stock.

An improved soy bean, Mammoth 152, yielding 7 bushels more per acre than the common Mammoth, has been distributed by the North Carolina station, and an earlier strain of Haberland 38 has been produced for the mountain regions.

The Connecticut State station has developed a new hybrid type of tobacco, a cross between Sumatra and Broadleaf, which has been fixed by selection and named "Connecticut Round Tip." This combines all the good qualities of the Broadleaf and Cuban varieties. More than 200 acres were grown in the State the past year, and it is meeting with great favor from practical growers. "Maryland Mammoth" tobacco, originated at the Maryland station, has given the

highest yield and sold for the highest price of any raised in the State. The Ohio station has developed a drought-resistant type of Montgomery seed leaf which is quite resistant to root rot and gives increased yields of about 30 per cent.

A new strain of wheat, named "Ashland," has been developed at the Kentucky station, which is being distributed. This averaged 2.3 bushels more per acre for seven years than the variety ordinarily grown.

At the North Carolina station seed of an improved strain of Leap's Prolific wheat, which has yielded 4 to 6 bushels more than the common strains, has been distributed in 22 counties with very favorable reports.

The Ohio station has produced a wheat-spelt hybrid which is wholly resistant to stinking smut, and attempts are being made to transmit this character in crosses with better bread wheats.

Common Federation wheat has outyielded all other varieties at the Idaho station and is being increased for distribution. A new variety has been found by the Utah station that has been tested both as a spring and winter wheat for dry farming. It has outyielded all others, surpassing Turkey Red by at least 25 per cent. It is being improved by pure line breeding. The Kansas station reports that the average increase in yield of Kanred wheat over other varieties for 10 years has been 4 bushels. In years when there is considerable rust among other varieties Kanred shows up still better. A summary of variety tests conducted at the North Dakota station for a number of years shows the general superiority of durum wheats as a class. Among the hard red spring wheats, Marquis was the best, but it is subject to rust. Kota showed a high degree of rust resistance.

Crop rotation.

In 30 years' experiments in crop rotation and manuring at the Missouri station the results show (1) that a four-year rotation of corn, oats, wheat, and clover gives the best results; (2) that crop rotation with no manure is practically as effective in maintaining the average yield in corn and wheat as is heavy manuring where these crops are grown continuously without rotation; (3) that averaging 30 years' yields, heavy applications of commercial fertilizers are as effective as heavy applications of barnyard manure in maintaining the total production in a six-year rotation of corn, oats, wheat, clover, timothy, and timothy; and (4) that rotation is more effective on the average than continuous cropping to grain crops, but is less effective than continuous cropping to grasses in maintaining the supply of soil nitrogen.

Experiments at the Wyoming station demonstrate the value of cultivated crops, especially potatoes, on the following grain crop. Summer fallow showed only slight gains, insufficient to cover expenses. In similar experiments at the Utah station peas and potatoes were more profitable when grown during the fallow period between wheat years than corn. Wheat after wheat, followed by an intertilled crop, was more profitable than where oats or barley took the place of one of the wheat crops. At the Washington station, when either vetch or peas were used as a green manure crop, the following crop of wheat produced only as high a yield as after good summer fallow, but the wheat was as high in quality. From an economic

standpoint, however, as far as immediate production is concerned, green manuring is not recommended.

In a study of residual effects at the Louisiana station a comparison was made of the effects on succeeding crops of cotton and oats of plowing under soy beans, crimson clover, cowpeas, and velvet beans. Velvet beans produced the largest yield of cotton for two years. When soy beans were introduced in a rotation of corn and cotton the yield of cotton was increased 100 per cent.

Corn culture.

The Montana station has conclusively demonstrated the great value of corn as a forage crop in dry farming in the higher valleys. It produces more than twice as much as any other forage crop grown without irrigation. In the lower valleys it is valuable both for grain and forage. It leaves the ground in excellent shape for a succeeding small grain crop, in many years being nearly equal to fallow.

The Missouri station finds that the character of the season is a limiting factor in the use of fertilizers for corn. If there is little rain during the summer the corn may be greatly reduced, but with good rains, well distributed, any system of application is profitable. With severe drought no application of fertilizers returned their cost.

A complete fertilizer applied in advance of the corn planter with a fertilizer drill at the rate of 300 pounds per acre gave the largest increase in yield, the second largest being from 250 pounds of a complete fertilizer drilled into the soil in advance of the planter and 50 pounds applied in the row at the time of planting.

In a trial of forms, rates, and carriers of nitrogen for corn at the Mississippi station nitrate of soda was best, 100 pounds giving an increase in yield of 16 bushels per acre. Two hundred pounds gave a little higher yield, but not enough to cover expenses. Sulphate of ammonia came next in efficiency, then cyanamid.

Tests at the Alabama station as to the best time to apply nitrate of soda to corn showed this to be when the plants are about 18 inches high. Similar tests at the Mississippi station gave better results when the application was made when the corn was very small. Corn that had been injured by too much rain showed a big improvement and gave paying returns where nitrate was used even when the corn was 2 or 3 feet high.

In tillage experiments at the Iowa station in which corn was cultivated only once or not at all the stalks were smaller in diameter and shorter and there was more smut than on cultivated plats. The amount of water utilized by weeds is of considerable importance, especially in times of drought. A comparison of deep and shallow cultivation at the Kentucky station showed little difference in the results, the shallow cultivated plats yielding 55 bushels and the deep 56 bushels. Cutting the weeds without cultivation resulted in a yield of 53 bushels.

In experiments at the Kentucky station, in which soy beans were planted thickly in the corn rows or in alternate rows, the combined yields of beans and corn were not as valuable as corn planted alone; but planting the beans at the rate of a hill to each hill of corn did not decrease the yield of corn materially, and the combined yield had a greater feeding value than the corn alone.

At the Louisiana station the greatest yield of corn and velvet beans was obtained when both crops were planted in the same row.

Tests of varieties for silage at the Idaho station show a variation of yield from 8.53 tons to 22.39 tons per acre on the basis of harvesting 100 hills of each variety. A summary of 5 years' tests at the Kentucky station gave a yield of 10.35 tons per acre of corn for silage and of 16.15 tons of sorghum for silage.

Detasselling did not materially increase the yield at the Nebraska station.

By germinating the seed in an ice box the Wisconsin station has secured strains of corn resistant to cold which can be planted from 10 days to 2 weeks earlier than ordinary corn and which are proving popular.

The Minnesota station finds that respiration is increased in stored shelled corn by raising the temperature within certain limits, by increasing the moisture content, by the presence of broken grains and damaged kernels, and by the termination of a period of partial dormancy following harvest.

The Wisconsin station finds that when corncobs are partially hydrolyzed and the resulting sugar solution inoculated with the proper bacteria, about equal quantities of acetic and lactic acids can be obtained, 1 ton of cobs yielding about 300 pounds each of acetic and lactic acids. This apparently has large commercial possibilities, as the United States produces over 20,000,000 tons of corncobs annually.

Cotton culture.

Tests of cotton varieties at the New Mexico station showed Durango to be one of the best for the State, yielding equally as well as some of the more common varieties, and the price received for the lint was practically double that for the shorter staple.

The Alabama station finds the best time for applying nitrate to cotton to be when it is from 3 to 5 inches high. A test of the different forms of nitrogen at the Mississippi station showed very little difference in yield when the same amount of nitrogen in each compound was used. Potash experiments with cotton at the Georgia station, on a clay loam soil indicated that very small applications of potash were as beneficial as heavy ones.

Experiments in thinning, at the Texas station, show that if this is done late the results are harmful rather than beneficial, and where the moisture supply is adequate, with proper cultivation and freedom from competing weeds and grasses, cotton may be left more thickly in the row than is usually practiced. Results obtained at the Mississippi station indicate that much closer spacing than has heretofore been practiced gives decidedly bigger yields, especially under boll weevil conditions.

Very satisfactory results were obtained at the Arkansas station in delinting cotton seed with sulphuric acid and planting the seed with a corn planter. Sunburning was found to be a very common cause of shedding of bolls.

The Oklahoma station finds no critical period in the formation of oil in cotton seed during growth. Season has a marked effect on the oil yield. The latter is dependent chiefly on the total yield of cotton per acre, and there is no great variation in the oil content of mature seed of different varieties in the same year.

Legumes.

Sweet clover investigations at the North Dakota station indicate that this crop may be safely seeded in the Red River Valley over a wide range of time from early April to the middle of June. Ten pounds of seed per acre is sufficient. The Idaho station also reports that this amount of well-scarified seed per acre gave the best quality and yield of hay. Annual varieties were found to be not so well suited to the climatic conditions of northern Idaho as the biennial strains. At the Oklahoma station spring planting and sowing the seed shallow in a well-prepared seed bed gave the best results. Studies at the Michigan station show that if sweet clover is cut too close the crop is ruined. Cutting as the buds start to form but before they are open, at a height of about 9 inches, was apparently best.

The Wisconsin station has introduced a yellow sweet clover from Canada that is much finer in stem and more leafy than biennial white sweet clover and that matures earlier, making a fine grade of hay. It will grow well on a variety of soils and the seed yields are more than double the biennial clover yields. It promises to be a valuable forage crop for the State.

The annual white sweet clover, Hubam, has been widely distributed by the Iowa station and the reports have been most encouraging. It is believed that it will prove to be especially valuable as a green manure crop to seed with small grain in the spring and plow under in the fall, that it will make an excellent fall pasture crop for cattle and sheep, and that it will prove to be a satisfactory emergency leguminous hay crop to seed when red clover or alfalfa fail.

In germination tests of hard seed of alfalfa, sweet clover, and red clover, at the Montana station, treatments including hulling, two rates of scarifying, and sulphuric acid were tried, the latter giving the highest germination.

A new species of vetch (*Vicia dasycarpa*) has been found by the North Carolina station that is smoother than hairy vetch and free from disease. This is being increased for distribution.

In a comparison of inoculated and uninoculated soy bean plants, at the New Hampshire station, all of the former showed a remarkable difference in color and in the number of root nodules as compared with the latter, and the leaves and stems contained 26 per cent more nitrogen.

The Oregon station reports that the Tangier pea, introduced by the United States Department of Agriculture from northern Africa, is proving an excellent silage crop, yielding 25 tons of green matter to the acre. A study of the water requirements of beans at this station showed, as a seven-year average, that 2,909 pounds of water was required for 1 pound of dry matter. When grown in rotation this was reduced to 2,249 pounds, and when treated with manure to 1,900 pounds. With irrigation, continuous cropping to beans gave a water requirement of 2,622 pounds, when irrigated and rotated 1,794 pounds, and when irrigated, rotated, and manured 1,425 pounds.

The Minnesota station obtained good results in the inoculation of legume seeds by using the same number of pounds of inoculated soil as of seed. Reports from the Wyoming station show that

good results were obtained by inoculation, especially on dry-land farms. The Wisconsin station found that this is not necessarily a growth factor, but results in an increase of nitrogen even when no increase in growth results.

It is reported by the Iowa station that it is necessary to inoculate for alfalfa on 90 per cent of the soils of the State, and that the application of lime is necessary in 70 per cent. Turkestan proved to be as hardy as Grim but gave lower yields, the latter giving four cuttings. The Kansas station reports that a decrease in yield of alfalfa followed all applications of over 200 pounds of sulphur per acre.

At the Kentucky station the organism in the nodules organism of soy beans was found to be entirely distinct from the alfalfa organism, and the two can not be interchanged. There is also a difference between the sweet clover and red clover organisms, but that of sweet clover is identical with that of alfalfa. Similar studies at the Wisconsin station showed that the organisms from alfalfa and sweet clover and from peas and vetch can be interchanged, but soy bean and clover cultures can not.

At the Wisconsin station the best results for nodule formation in legumes were secured in a slightly acid or neutral medium and no nodules were produced where there was much alkalinity.

Potato growing.

Investigations at the Maryland station showed a direct correlation between the size of the seed piece and the size of the sprout. In Irish Cobbler a direct relation was found between the dominance of the apical buds and the yield. When immature potatoes are planted it is found that they go through a rest period and become mature before growth starts. With late potatoes there is a transfer of starch from the large tubers to the small ones, if growth is checked, and therefore digging should be done as soon as possible after the tops are killed by frost.

The South Carolina station reports that successful potato seed production is largely a matter of the production of viable pollen and that environmental conditions also have an important bearing. At the Washington station 22 lots of Netted Gem potatoes for seed, secured from different localities in the State, varied in yield from 3,764 to 13,952 pounds per acre.

In tests of the use of dryers for potato seed pieces, those receiving no treatment resulted in less decay than those treated with gypsum, rock phosphate, or sulphur. The New York State station reports that plants from similar halves of the same tuber often differ widely in yield without apparent cause, showing that improvement by hill selection can not be carried to a high degree of perfection.

Tests at the New Jersey station showed that potato seed pieces larger than three-fourth ounce increased the yield. Evidence was secured that the more immature the tuber the better its purpose for seed. Similar results were obtained at the Pennsylvania station, the immature seed giving an increased yield. The Rhode Island station finds that good seed potatoes are high in nonprotein nitrogen compounds.

At the Nebraska station no degeneration was found where potato seed was grown with minimum irrigation, but it did occur under

the regular irrigation practiced. Under dry-land conditions seed can be maintained for a series of years without degeneracy. Under irrigation tubers have degenerated rapidly during a series of years and become practically useless for seed. Small tubers from high-yielding strains give as good results as large tubers. Tuber line strains grown on dry land and taken to irrigated land break up under one or two years of irrigation and are worthless after about three years. A comparison of seed from irrigated and dry-land sources gave a gain of 80.3 bushels per acre in favor of the dry-land seed stock. Western Nebraska seed was equal or superior in yields to seed from Minnesota and much superior to eastern Nebraska seed.

The Iowa station found high temperature to be the most important limiting factor in potato production in the Corn Belt. There was a difference of 50 per cent in yield in favor of early planting.

Sunflowers.

A number of stations have been engaged in a study of the sunflower as a silage crop, with results that demonstrate its value, especially in those sections where corn can not be depended upon to ripen. While its nutritive value and palatability are somewhat below corn silage, this is to some extent compensated for by the larger yields obtained. The New Hampshire station obtained a yield of 22.58 tons per acre, which was 70 per cent higher than the average yield of corn. The Oregon station reports a yield of 54.7 tons, green weight, per acre under irrigation. The Michigan station reports that special plates can be made for the corn planter which will handle sunflower seed satisfactorily. Mammoth Russian is the variety recommended by practically all of the stations.

Date and rate of planting have been tested at a number of the stations, early planting being recommended. At the Michigan station the best results were obtained in planting from May 15 to June 1, and 6 to 8 pounds of seed to the acre, in rows 30 to 36 inches apart, gave the maximum yield and the best quality of silage.

At the Idaho station 8-inch spacing produced a tonnage 68 per cent greater than 30-inch spacing. The Minnnesota station reports that close planting gave a better quality of silage, which was less coarse, woody, and fibrous than that from wider spacings, and also notes the fact that early plantings give the highest yields. At the Nebraska station early plantings gave twice as much tonnage as corn, but the yield fell off rapidly with later plantings. Such early plantings, however, were found to be attacked by a leaf rust, which greatly reduced the quality of the silage. The Oregon station recommends seeding with a grain drill in rows 21 inches apart at the rate of 25 to 35 pounds of seed per acre. The Wisconsin station reports the best results when not planted closer than 6 inches apart in drilled rows.

At the North Dakota station sunflowers made much more growth in the same length of time than corn, and withstood prolonged cool weather better, even considerable frost in the spring.

In harvesting, the Nevada station recommends cutting when the crop is about 50 per cent in bloom, for if left longer birds get much of the seed. The Michigan station reports that sunflowers should be cut for silage when from one-tenth to one-third in bloom. Ordinary corn-harvesting machinery was found to be satisfactory

for harvesting sunflowers. The Oregon station recommends harvesting any time from full bloom until the seeds are in the stiff dough stage. At the Wisconsin station the best results were obtained by cutting when the plants average one-third in bloom, the silage from early cuttings being eaten readily with no decrease in milk flow, although somewhat more acid than corn silage.

No advantage was found in planting corn and sunflowers together in the row, but by planting alternately two rows of each good results were obtained.

Determination of the plant food removed by this crop at the Montana station shows it to be a heavy feeder, especially of potash. It is not recommended as a silage crop for the State by the Pennsylvania station, except in such localities where corn is not a sure crop. The silage showed a distinct lack of palatability, and cattle did not relish it as well as a good grade of corn silage, and cows produced only 86.4 per cent as much milk on a ration containing a normal amount of sunflower silage as compared with a good corn silage. At the Oregon station, however, it is noted that stock left choice alfalfa hay for sunflower silage. It was improved by silaging with corn or oats. The effectiveness of the sunflower crop in controlling weeds is noted at the Wisconsin station.

Sweet potato storage.

Observations at the Mississippi station on sweet potato storage show that well-cured potatoes can be carried as low as 32° F. without damage. Potatoes left in the ground three days after a killing frost will not keep and are not fit for food. Similar studies at the Alabama station show that temperature, even that above the frost point, seems to be a factor in the keeping quality. If harvested before frost the results have been good, but if the vines are cut or chilled the potatoes will not keep.

Tobacco culture.

The Massachusetts station finds that tobacco reaches its best development on soils showing a medium lime requirement. The results of studies at the Virginia station indicate that it is best to grow bright tobacco on a poor soil and add the necessary plant food, as the tobacco tends to be dark if the soil is too rich. The best results were obtained with a rotation of tobacco, wheat, and redtop. In a study of sources of nitrogen for bright tobacco, the best results were obtained with inorganic forms, for the first year at least. The North Carolina station reports that a small amount of magnesia in fertilizers prevents what is known as "sand drown" in tobacco.

Studies at the Kentucky station on the tolerance of tobacco to sodium nitrate concentrations show that with concentrations greater than 1 part to 3,750 parts of water the plants begin to wilt, and if the concentration reaches 150 parts to 3,750 the injury is permanent. The best general results were obtained with a strength of 2 to 3 parts to 3,750, the plants soon recovering from the initial drooping. It is also found that if heat can be properly applied in large barns at an economical cost, losses due to unfavorable weather at curing time can be eliminated and the average quality of the cured leaf improved. Studies on the cost of production showed that on an average of 81 farms in the Burley district, 375 hours of man

labor and 98 hours of horse labor were required to produce and market an acre of tobacco. For the dark-fired tobacco the labor was 26 hours of man and 6 hours of horse labor.

Wheat culture.

The Maryland station reports that 70 per cent of the wheat acreage of the State is of the higher yielding varieties introduced by the station, and it is estimated that 1,500,000 bushels have been thus added to the annual yield.

At the Minnesota station large ungraded and small wheat seed, sown at the same rate per acre, gave equal yields on both medium and highly productive soils. Seedings of winter wheat from September 1 to 10 gave higher yields than those made later.

Tests at the North Carolina station showed that earlier plantings, up to October 1, of wheat gave better early growth, but all were damaged by rust. The best results were obtained with both crops from plantings from October 1 to 30 and with 80 pounds of seed to the acre. The Virginia station also reports that early seeded wheat is attacked by rust more than is late seeded. Two good strains of wheat were developed and distributed.

Tests at the Washington station show that where nitrates are not limited the lightest seeding of winter wheat produces the greatest amount of tillering. This, however, is not strictly inversely proportional to the rate of seeding, but the heaviest seeding produces the greatest number of culms per unit area. The number of culms per acre can therefore be controlled in part by regulating the rate of seeding, a matter of practical importance from the standpoint of its effect on lodging and "burning."

At the Idaho station applications of sodium nitrate, ammonium sulphate, or hydrolyzed wheat extract, or of potash and phosphorus to poor soils, increased the protein of wheat. The experiments showed the important part that a liberal supply of available nitrogen in the soil plays in the elaboration of protein in the wheat kernel. Studies at the California station show that the time of application of nitrogen to wheat has a direct influence on the hardness. There is also a varietal difference in the response of wheat to nitrogen. Tests at the Washington station show that with a good supply of nitrogen a much smaller amount of seed than otherwise would be required will give a good stand. Cultural experiments with winter wheat showed no consistent advantages from harrowing the crop in the spring, and while in some instances the harrowed crop equaled the unharrowed, it was not superior, and in many instances was less.

At the Rhode Island station wheat, grown in plats that were neutral in reaction and receiving nitrate of soda, was chlorotic, abnormal, and yielded only 11.3 bushels. On plats not quite neutralized and receiving ammonium sulphate the plants were of the normal green color and yielded 23.1 bushels, indicating that slight acidity is desirable for this crop.

Samples of frosted wheat, at the Montana station, showed poorer baking qualities than unfrosted, but after a few months of aging the baking quality of the frosted samples was greatly improved. On separating some of the amino compounds from severely frosted wheat, and adding these to good flour, a larger loaf and better texture were obtained.

The Minnesota station has found that the ratio of gas produced in doughs to the gas diffused out of such doughs is a useful basis of evaluating flour strength.

Oat culture.

The Alabama station reports that applications of acid phosphates to oats appeared to increase somewhat resistance to winterkilling, but had little effect on yield. Continuous planting of fall and spring oats with seed from the same source for both plantings, which has been carried on for 17 years, shows the fall plantings to give slightly higher yields, but the spring plantings were four or five days earlier.

At the Minnesota station small oat seed gave decidedly less yield than large or ungraded seed, when the same number of seeds per acre were sown. Large and ungraded seed gave approximately the same yield when the same number of pounds per acre were sown. Primary kernels yielded more than secondary kernels.

Tests at the North Carolina station showed that earlier seedings of oats gave better early growth.

Studies on the lodging of grain at the Ohio station show that when oats are seeded above 9 pecks to the acre they lodge badly, which is also the case when small seeds are used. Commercial fertilizers and heavy manuring also caused lodging. It occurred particularly in thick stands, and the diameter of the straw was found to be less under these conditions. Plats of shaded grain lodged in a windstorm which unshaded grain withstood. The grain also went down worse on plowed plats than on disked ones, and it is noted that in the former more nitrates were produced. Weak stems were found to stool more abundantly.

The Virginia station has developed and distributed a good strain of oats.

Seeding grain.

Very early seeding of grain was found to be preferable at the Wyoming station, both from the standpoint of moisture and of early maturity. While the early seeded grains make little growth the first few weeks, they ripen earlier, escaping early frosts. Wheat, oats, and barley seed were found to germinate well when cut at an early stage of maturity.

At the Minnesota station a mixture of early oats and barley yielded more than either crop alone. Medium-maturing oats alone produced more pounds per acre than the early oats alone or in mixture with barley. Wheat and medium-maturing oats mixed yielded less in pounds per acre than oats alone, but more than wheat alone.

Improvement of pasture.

At the Nevada station the improvement of old pastures in the Humboldt Valley has been very successfully accomplished by cutting down the irrigation water, which was causing a growth of the coarser grasses and sedges, and by shallow plowing and disking. A shortage of water produced no unfavorable effect upon the wild grass, and under intermittent irrigation the yield of the more desirable grasses and clovers was increased.

At the Florida station Bahia grass is proving promising for summer pasture, growing well on light sandy soil and improving the grazing. It is, however, killed to the ground by frost.

Weed eradication.

Quack grass was successfully eradicated on two infested fields at the Wisconsin station by growing Sudan grass. At the New Mexico station chemical treatment for the eradication of Johnson grass was not found profitable. Close pasturing with goats, after which the field is plowed, all roots and stalks raked out, and the field planted to cereals, has given the best results. From nine years' study at the Iowa station the most resistant weed seeds were found to be butterprint, curled dock, jimson weed, horse nettle, five finger, and the honey locust tree.

Experiments at the Minnesota station showed that good cultural methods are an economical way of controlling and eradicating the perennial sow thistle.

Miscellaneous.

A comparison of black-hull kafir and corn by the Missouri station on the thin dry soils of the Ozark region showed an average yield of the former of 27.9 bushels of grain, compared with 7.7 bushels of corn.

A strain of feterita, named "Spur," that yields over 7 bushels of seed per acre more than the parent varieties, has been developed at the Texas station.

Crop irrigation studies at the Utah station show that sugar beets require 27 to 33 inches, potatoes 21 to 27 inches, and alfalfa 30 to 36 inches in four or five applications. Transpiration and evaporation losses were found to be very great, 4 acre-feet being the maximum for alfalfa.

Tests by the Arizona station show that Sudan grass is successful in all parts of the State at elevations below 6,000 feet and of limited value at higher elevations.

FRUITS.

Improvements of fruits.

Studies at the New York State station show that the most effective course in breeding for the development of fruits is to use as a male parent a seedless fruit, which is usually strongly staminate, on a nearly seedless fruit which does produce a few viable seeds.

Extensive apple-breeding experiments at the Idaho station have resulted in a cross between the Wagener and Ben Davis, which is at least a month earlier than the Wagener and has a season extending beyond the Wagener. A new apple variety of great promise has been developed at the Iowa station, which has been named the "Ames." It has a good red color, is vigorous and hardy, of excellent quality, productive, and of good keeping qualities.

The Oregon station has developed a cherry seedling that is vigorous, a heavy bearer, free from gummosis and from freeze injury, that promises to be of value. At the Mississippi station a cross has been secured between the cherry and plum that gives indications of being of great value.

A promising seedling prune has been developed at the Oregon station, bearing a fruit with a higher sugar content than any variety tested. It is a freestone and is excellent for drying.

At the California station a Persian variety of grape, Black Monukka, has been found especially valuable as a table and raisin

grape and is a heavy bearer. The fruit is being shipped to New York from the Imperial Valley as a table grape.

At the Oregon station cross-pollination of the strawberry had no effect upon yield, earliness of maturity, or quality of fruit, and the Vermont station finds indications that self-pollination has little or no effect on quality, but does have some on size and earliness of the fruit. Blackberry studies at the latter station indicate that a species which responds to both the recognized systematic and genetic criteria for species may arise as the result of hybridization. A raspberry-dewberry cross originated at the Texas station is being distributed and promises to become of economic importance. It has been named the "Ness," in honor of its originator. The fruit is large and attractive in color, of good quality, and an abundant bearer. It crosses readily with all species of Rubus and the progeny are self-fertile. At the New Hampshire station a high-bush cranberry is being introduced as a substitute for gooseberries and currants, which are being eradicated to save the white pine of the State.

Fertilizers and cover crops.

Delaware station experiments on fertilizers for the apple orchard show that every kind used has uniformly increased yields, although increase in yield has not kept pace with increase in the amount of fertilizer used, indicating that moderate fertilization is most economical. At the West Virginia station applications of nitrogen are showing marked effect in both vegetative growth and fruit production.

Studies at the Michigan station showed that the poorest results in the limed portion of the orchard were better than the best treatment without lime, as far as growth and some other factors were concerned. Trees grown under control at the Wisconsin station showed an increased nitrogen content in the new growth where nitrate was applied liberally, and it is believed that fruiting depends on the optimum relation of nitrogen supplied from the soil and the amount of carbohydrate material which the leaves can construct.

In experiments at the New Hampshire station, plats receiving fertilizer in addition to cultivation and cover crops showed the greatest growth as measured by trunk diameter and twig growth. The yield from the fertilized plats was 50 per cent higher than from the unfertilized, and it is believed that the bearing is more regular in the former. Analysis showed shaded trees to be higher in moisture and total nitrogen and lower in free reducing sugars and starch. The effect of shading is most noticeable in the amount of carbohydrates synthesized by the leaves and stored in the fruit spurs. Girdled trees were lower in total nitrogen and moisture and higher in free reducing sugars and sucrose than ungirdled. Fruit-bud formation was increased in the girdled trees.

The Pennsylvania station finds that apple orchards in sod can not be conducted at a profit without the use of nitrogenous fertilizers. Those under clean culture gave practically no response to such fertilizers. The addition of 150 pounds of nitrate of soda per acre to sod orchards as a rule gives large increases in yield, but the use of mixed fertilizers has not paid the cost. Northwest Greening trees on clover sod, at the Iowa station, for a period of 10 years have produced 3 bushels more per tree than those on continuous blue-grass sod. The latter produced terminal growth which lacks sufficient

vigor to form lateral fruit buds necessary for fruit production in succeeding years, and the buds at the base of the leaf seldom have strength enough to push out growth the following year. Sunlight was also found to be an important factor, trees having the greatest exposure being the heaviest producers.

The Maine station finds that the development of the apple depends on the food supply available and on the seed content. Dropped fruit contains fewer seeds than the fruit remaining on the tree.

The Washington station finds that lack of complete fertilization of the blooms is a contributory factor to the June drop of apples.

Peach fertilizer experiments at the Virginia station showed that nitrogen and potash give the highest yield, nitrogen and phosphorus next, and nitrogen alone, next, but there is a difference in varieties in this respect. Phosphorus alone did not give any effect at first, but is beginning to show effects after two or three years.

At the Arizona station the air temperature was found to be 6° to 8° F. lower, the soil temperature 5° to 7° lower, and the humidity of the air 10 to 15 per cent higher in cover-cropped orchards than outside. Cowpeas as a summer cover crop caused grapefruit to retain their green color during the winter.

Applications of nitrate of soda to Satsuma oranges, at the Alabama station, gave a 100 per cent increase in yield, but the quality of the fruit grew poorer with the increase.

Hardiness.

At the New Hampshire station there was found to be little difference in the amount of injury done by exposure for different lengths of time to a temperature of —7.8° C. A markedly greater injury was done to roots by freezing them rapidly than by slowly lowering the temperature. Greater injury was done in wet than in dry soils. Air-dried roots showed less injury than normal, turgid roots. Some seedling roots were more hardy than others.

A hardiness factor for the apple has been worked out by the Iowa station by combining the depression of the freezing point and the moisture percentage, the best time to determine these being during the blooming period. A trial of Grimes Golden on about 20 different hardy stocks showed a wide difference in the amount of growth, depending upon the type of graft union made by the scion with the stock.

Winter injury to fruit trees has been investigated at the Washington station and is believed to be due to lack of sufficient nitrates to resume normal growth in the spring. Two factors seem to be involved, a soil solution heavily charged with mineral salts and an extremely fluctuating nitrogen content of the soil. The trouble is more noticeable in semiarid soils. Nitrification takes place in the fall and spring, but in May the soil moisture decreases, nitrification slows up, and the leaves do not develop normally, but form rosettes at the end of the twigs. The application of nitrate of soda gave some improvement in the succeeding year and the plowing in of clover corrected the difficulty.

At the Missouri station a correlation has been found between the pentosan content and hardiness of shoots from fruit plants. The study indicates that pectin-like water-soluble pentosans are the most important water-holding substances in the tissues of fruit plants.

Similarly, histological studies of apple leaves at the Colorado station indicate that winterkilling injury is not due so much to freezing as to drying out of the tissues.

At the Nebraska station scion roots were found to stand a lower temperature than the roots of the French crab used for stock, indicating the desirability of propagating so as to get as many roots as possible from the scion. The critical temperature for apple roots is found to be from −6° to −10° or −12° C. In making crosses with the object of increasing hardiness, the South Dakota station has secured a wild crab apple from Minnesota which is giving very promising crosses with several apple varieties, some of which are being propagated for distribution. New pear hybrids have also been secured which are hardy and withstand blight.

Sterility in apples.

Studies of the cause of sterility at the West Virginia station show that in some varieties so many pollen tubes grow down into the pistil that fertilization can not take place. This is true with Rome and Rome pollen, but not to the same extent with other pollen.

At the California station Gravenstein and Spitzenberg were found to be largely self-sterile, Jonathan giving the best results for the pollination of Spitzenberg, and Delicious for Gravenstein. Belleflower was also found to be practically self-sterile.

Setting of fruit.

Fruit-bud formation has been studied at a number of stations. The Virginia station finds this to be about equally affected by cultivation and nitrogenous fertilizers, but in different degrees. In general, cultivation gives better results than fertilizers. Results at the Missouri station show that the amount of growth is closely related to fruit-bud development. When spurs have attained bearing size the nitrogen content is considerably increased, and this also seems to be true of phosphorus. Spring applications of sodium nitrate gave no indication of an increase of nitrogen in the bark or spurs, while fall applications did increase the nitrogen in the bark. Starch accumulation was found to be greatest during June when the highest percentage of fruit-bud differentiation occurs, and these spurs are characterized further by a rise in the total nitrogen content of the two-year-old wood.

A study of the composition of fruit spurs by the Wisconsin station shows them to be rich in glucose, with less xylose and a little galactose. The hemicellulose disappears quite rapidly from the fruit spurs at the time the fruit is being formed, and is laid down quite rapidly when the leaves begin to function. The capacity of an apple tree to fruit seems to depend not only on the number of fruit spurs formed, but also on the amount of hemicellulose material.

Studies at the Oregon station on defoliation show that the setting of fruit is almost exactly proportioned to the number of leaves left on the tree. Irregular shaped apples generally lack seed in some of the carpels.

It is found at the Maine station that bud variation plays only a very small part in the yield, which may be largely due to the kind of stock and the soil in which the tree grows.

Identifying varieties.

Data have been secured at the Massachusetts station whereby the trueness to name of certain standard varieties of fruit trees may be determined from their growth in the nursery row.

Pruning apples.

Pruning experiments at the Virginia station demonstrate that a high head type of pruning delays maturity and reduces size, and heavy heading prevents bud formation. Summer pruning was disastrous, weakening the growth as well as preventing fruit bud formation. On unpruned trees the bloom comes on the fourth year's growth; on trees well thinned and headed lightly, on the fifth year's growth; and with normal pruning, on the sixth year's growth. Apple trees show decided differences in character of growth with differences in fertilization and culture.

Pruning studies at the West Virginia station showed that great variations in leaf structure results from different methods of pruning. Leaves formed after early pruning are found to have more of the palisade layers of cells. Different pruning methods also affect differently the development of the root system, which bears a close relation to the top, trees with large above-ground growth having a large number of feeding roots. Pruning dwarfs the trees, and while heavily pruned trees made the best growth at first, after three years they fell off rapidly. The dwarfing effects of pruning on the tops were accompanied by a dwarfing of the root system. Early summer pruning dwarfed the trees more than heavy dormant pruning. Long pruning has been found to be best for olive trees at the California station.

Fruit storage.

In apple storage studies at the Iowa station it was found that "Jonathan spot" develops largely in late picked apples, and that early picking and immediate storage will almost entirely eliminate it. Circulation of air in the storage room by the use of small fans prevented soft scald in the Jonathan apple. On the other hand, early picked or immature Grimes Golden developed scald badly in storage. They should be picked when as near maturity as possible, stored immediately, and the period of storage should not extend much later than January 1.

At the California station it was found that too high temperature in many cases delays the ripening of some varieties of fruit. Normally matured fruit was found to hold up better in flavor, color, etc., in storage. Fruit that had been picked green was found to keep better at a temperature of 36° F. For avocados the best results were obtained at 45°, the fruit not ripening well at a lower temperature. The color and flavor of such fruits as cherries, berries, figs, etc., were maintained for a year or more by freezing, but the texture softened somewhat, except with figs and cherries. A slight addition of sugar resulted in better retention of the color and flavor.

Peaches.

The Georgia station emphasizes the necessity of keeping the peach orchard in a good, clean, healthy condition, pruning out the mummies and cankered wood, and cutting out near-by plum thickets.

By these means it is found possible to nearly eliminate the curculio and brown rot, for which spraying or dusting alone should not be depended upon.

In fertilizer tests with peaches at the Illinois station the number of flowers per spur was increased and there was a better distribution on the shoots when potash was applied.

Cytological examination of a large amount of material at the Delaware station gives no evidence that June drop is caused by improper or incomplete fertilization.

The Maryland station finds that the dormant period of the peach bud ends about January 1 in that State, and as the temperature rises above 43° F. growth begins. There is a direct correlation between the air temperature and the moisture content of peach buds.

At the Arizona station the actual water requirements of individual peach trees during the first growing season of seven months was found to be 190.25 gallons.

Grapes.

Early fall pruning of grapes by the South Carolina station produced no injury when sodium silicate was applied to the cut surfaces to prevent bleeding. The Georgia station found root grafting to offer the greatest possibilities in facilitating root formation of muscadine cuttings.

Pecans.

The Georgia station finds that the early dropping of pecans is at least partly due to faulty pollination, with indications of a possible remedy in soil treatment. Pecans under cultivation gave a 50 per cent better crop than those on sod at the Mississippi station. The New Mexico station has a number of varieties that are beginning to bear, and it is believed they will be a successful crop for the Southwest. All varieties of filberts tested at the Oregon station were self-sterile, necessitating cross-pollination.

Vinegar from frozen apples.

The Iowa station reports that a good grade of vinegar can be made from frozen apples. The formation of acid was found to begin before alcoholic fermentation was complete.

VEGETABLES.

The North Dakota station has developed an improved strain of Earliana tomato that has been distributed to growers, some seed houses making a specialty of it. At the Oregon station 80 per cent of pollinated tomato blossoms produced marketable fruit, as against 50 per cent on unpollinated plants. No advantage was found by the New Mexico station in forcing tomatoes in cold frames, except for extreme earliness. For the main crop, field-planted tomatoes proved best and appeared to be less subject to disease. Fertilizer experiments with tomatoes, at the Missouri station, showed phosphorus to be the limiting element of plant food, and when the supply of nitrogen becomes limited blossoms fail to set fruit.

The Louisiana station reports that sweet corn may be so planted, using Stowells Evergreen and Howling Mob, that it may be had over a period of 10 to 12 weeks. At the Iowa station there is found to be

a greater variation in the sugar content between sweet corn processed immediately and that held for 24 hours than there is between the lots from the various seed sources when processed and handled under identical conditions. As sweet corn passes from the stage in which it is graded as extra standard pack to the substandard grade, the pericarp undergoes a thickening of the cell walls, making it about three times as tough.

Fertilizer experients with celery on muck soils, by the New Jersey station, indicate the advantage of using a moderate application of fertilizer mixtures low in nitrogen, high in phosphorus, and low in potash, such as a 2–10–4 or a 4–6–6 mixture.

At the Maryland station studies in onion dormancy showed no growth in storage at a temperature as low as 30° F., but considerable evidences of internal growth at 40° F. There was a dormant period of from 6 to 8 weeks, after which growth was resumed. Transverse cutting of the bulb started growth, the time when this was resumed being proportional to the nearness of the cut to the growing point.

In work with beans at the New York Cornell station, selection within pure lines, for size and shape of seed, for several generations, did not change these characters nor did it have any effect in changing the size of the eye in yellow-eyed beans.

Canning spoilage.

Canning studies at the Colorado station with corn and peas, processed for different periods at the boiling point of water (94.5° C. at the station), showed that spoilage was greater with corn than with peas under the same conditions of treatment. Spoilage resulted in all of the peas heated less than three hours and in all of the corn even when heated for five hours.

DISEASES OF PLANTS.

Apple diseases.

In studies on the root rot of apples at the Virginia station Northern Spy was found to be the most resistant variety, the percentage of infection being only 17 as compared with 78 in seedlings. The organism most commonly present is *Xylaria digitata*, often accompanied by *X. polymorpha*. It is not believed that an infected tree can be cured, the best treatment being to replace with Spy roots. It usually kills the tree in from 6 to 12 years. Dusting experiments for the control of the scab showed sulphur to be superior to copper dusts. None of the dusting materials used proved sufficiently effective in the control of bitter-rot of the apple to warrant their use.

One hundred per cent control was secured at the Massachusetts station in spraying for the control of scab and black rot of apples, when this was thoroughly done. The new growth must be kept covered with spray ahead of the ejection of the spores. At the Minnesota station excellent results were obtained in the use of sulphur dust in controlling apple scab and other apple diseases, and it can be applied much more quickly than sprays.

Life-history studies of apple rust at the Virginia station show that it spends 3 months on the apple and 21 months on the red cedar, which it occasionally kills. It also occurs on the wild apple. The

West Virginia station reports that territory where cedar eradication was carefully carried out is practically free from rust, adjacent territory suffering great losses.

The New York State station has shown that the fungus *Nummularia discreta* is parasitic and is the cause of apple blister canker. Indications point to the mountain ash and other plants as intermediate hosts. A coat of shellac followed by coal tar is found to be the most satisfactory dressing for priming wounds. At the Iowa station this trouble is observed to be a secondary infection on trees which have been injured by winter drought, overproduction, or anything which lowers the vitality of the tree. For treatment this station recommends cutting out the cankered portion and painting the wound with white lead and raw linseed oil containing 1 ounce of mercuric chlorid to 2 quarts of paint.

At the Oregon station one spraying with Bordeaux mixture in August gave almost 100 per cent control of apple anthracnose. The Washington station reports that apple rosette is rapidly disappearing with better irrigation, the use of fertilizers and cover crops, and pruning.

Peach diseases.

The Georgia station finds that brown rot of peaches starts as a blossom blight in the early varieties. The mummies remaining on the trees over winter produce conidia and the early maturing varieties are attacked. It spreads especially after rains.

The Delaware station has made extensive studies of peach yellows and little peach. No great difference was found between the anatomical structure of healthy and diseased tissues, but striking differences were found in the storage products of metabolism, diseased tissues showing a much higher starch content and more crystals in the corticular tissues. Gum plugging of the cells of the medullary rays was very evident in diseased wood. Blossom buds of the "yellows" shoots showed much earlier maturity of pollen mother cells than in healthy buds.

At the Virgina station sulphur proved superior to copper dusts for control of scab.

Citrus diseases.

At the California station the bacteria causing citrus blast has been found to have a low optimum temperature and to disappear with the advent of hot weather. It may be controlled by spraying early in November with Bordeaux mixture. It has been found possible to induce a number of orange diseases by the use of chemicals. A lack of lime results in the dropping of the leaves, which are more or less chlorotic. The bacterial gummosis of stone fruits has been found on peaches and on nursery stock.

The Florida station reports a varietal resistance of citrus to melanose. The pineapple orange is badly affected by this disease, but has practically no stem end rot. Avocado scab was found to be the same as citrus scab and the disease appears to be spreading to other hosts.

Other fruit diseases.

Studies on Sclerotinia, at the Maryland station, show that a period of dormancy is not essential in the life cycle of *S. cinerea*, and that

apothecia are formed on fallen fruit during the first season. These appear to be strains of *S. cinerea* with differences in cultural behavior and response to temperature, but no morphological differences have been recognized.

Spraying apricots for brown rot has been satisfactory at the California station, if the application is made at the time the petals are beginning to open.

The Wisconsin station has successfully controlled cherry leaf spot, which has been quite serious, by three applications of Bordeaux mixture 3–3–50, applied (1) just after the petals fall, (2) about two weeks later, and (3) soon after harvest.

At the Arizona station three species of fungi and one of bacteria were isolated from rotting dates. Species of Alternaria and Macrosporium appeared to be the dominant parasites. The leaves were found to be affected by the fungi and the disease is believed to spread from them to the fruit.

The results of studies on anthracnose of black raspberries, at the Wisconsin station, show that two sprays, one a delayed dormant spray of lime sulphur, 1 to 10, or Bordeaux, 6–6–50, after the first two or three leaves have unfolded, and a summer spray of lime sulphur, 1 to 40, or Bordeaux, 3–3–50, about one week prior to blossoming, with the addition of an adhesive, give good commercial control.

A study of pineapple diseases at the Florida station shows that new slips are apparently more resistant to wilt than old plants. Sterilization of the soil and fertilization have been of no value in controlling the disease. Slips from healthy plants from other localities do better, and those fumigated with hydrocyanic acid do better than unfumigated ones. There are some indications that the disease may be caused by improper breeding and running down due to poor selection.

The California station finds that walnut catkins infected with blight can carry the disease through their pollen.

Corn root rot.

Root rots of corn have received attention from a number of the stations. At the Indiana station tests were not successful in producing root rot by inoculations of the organism where there was no injury to the tissues at the nodes by metals, especially aluminum which combines with the proteids and causes discoloration and decomposition. Iron and aluminum in the soil seem most injurious when there is a deficiency of calcium or phosphate. The stalks may break down and fail to grow even if the organism does not gain entrance. The trouble is considered largely a result of physiological disturbances. The disease may get into the kernels which may then carry infection. Plants having the highest metal intake are most subject to the disease. There seems to be a possibility of developing resistant strains by selection and breeding.

The Illinois station finds change in the H-ion concentration of the sap a result and not the cause of root rot. Rainfall has considerable influence on the alkalinity or acidity of the sap. At the Delaware station four corn diseases are found to be carried internally in the seed, all of which may cause root rot. Forty per cent are found to be infected with *Cephalosporium sacchari*, 20 per cent with

Fusarium moniliforme, 6 per cent with *Gibberella saubinetii*, and 5 per cent with *Diplodia zeae*. Scab of wheat was found to be an important cause of root and ear rot of corn, and is transmitted through internal infection of the seed. Corn should not, therefore, directly follow wheat.

The Arkansas station has studied a bacterial root and stalk rot of corn that was affecting quite an area over the State and in neighboring States. An organism which resembles that described by Burrell about 1890 was isolated, and inoculation experiments showed it to produce a rotting of the roots and stalks at the nodes and a spotting of the leaves.

It was found at the Kentucky station that *Fusarium moniliforme* was present in practically all seed corn. Partial control may be obtained by using only ears the seedlings of which show a high degree of resistance to the rot when tested. Plants which ripen their ears at the usual time but remain green for a period following ripening, are found to produce more resistant seedlings than those which die previous to or at the time of ripening of the ears.

The Louisiana station also reports the widespread occurrence of *F. moniliforme* as a cause of root rot, and that a white flint corn has been developed which is quite resistant. It is thought that the same organism causes root rot of sugar cane. Its effect on corn is to stunt the growth, diminishing the yield about 50 per cent.

Corn ear mold.

Studies on corn ear mold, at the Iowa station, show that the dry-rot organism will only thrive under conditions of excessive moisture and high temperature. It grows best at a temperature of 86° F., and shows no growth at 55° F. There is little evidence of systematic or continuous infection from the roots up to the ears.

Cotton diseases.

Cotton anthracnose, which formerly caused a loss of from 2 to 5 million dollars annually in South Carolina, is now practically under control, with negligible losses, largely as a result of investigations at the South Carolina station. Preliminary drying and one-year storage of the seed apparently will control this trouble. The angular leaf spot of cotton was also studied by this station, which finds it to be seed borne and not carried in the soil. Absolute control is secured by delinting the seed with sulphuric acid and treating with mercuric chlorid, which also reduces the infection from anthracnose and insures quicker germination. The disease is spread by rain but if fields are separated by corn it will not spread in this way.

A new disease of cotton, noted by the Arkansas station, is found to be due to a *Phoma* sp. The organism has been isolated, its life history worked out, and its pathogenicity established by inoculation experiments.

The Texas station finds that the organism causing Texas root rot, *Ozonium omnivorum*, carries over winter not only on fleshy roots, such as sweet potatoes, carrots, or beets, but also may live over on cotton plants, the roots of which remain alive during the winter. Indications are that it is not carried over in the soil. These facts suggest effective means for its eradication. Studies of resistance

showed that guar (*Cyamopsis psoralioides*), an Indian legume, is completely immune.

Mosaic disease.

Investigations at the Iowa station indicate that the mosaic of Cucurbitaceæ and Solanaceæ are different strains, as they have not been successfully cross-inoculated, but they can be cross-inoculated between members of the same order. The disease may overwinter on the common wild ground cherry. Outbreaks of mosaic on tomatoes have been noted, accompanied by outbreaks on near-by wild species of the ground cherry. Field roguing and simple hand dusting machines, such as are used for combating insects, will hold it in check.

Investigations by the Louisiana station show that mosaic of sugar cane is world-wide in its occurrence, and selection seems to be the only promising means of control. The selection of disease-free stalks for propagation has been quite successful. L 511 is the most resistant variety found as yet. The disease occurs on corn and is more severe on that crop.

Studies at the Georgia station show that pepper mosaic attacks both pimento and bell peppers. Its transmission by insects, especially the spinach aphid, the green and pink potato aphid, and probably others, is well established, and spraying for these insects is advisable. Wild host plants have not been found as yet. Further studies showed mosaic of Lima beans to be transmissible in the seed, and that different strains of the same variety of potatoes differ in susceptibility. Rosette of prunes is also a mosaic disease and is infectious. That of the peach can be carried to the plum, cherry, and apricot, and can be inoculated into the wild plum. It is believed that aphids may be responsible for its spreading. Indications are that resistance to this disease is transmitted to susceptible hosts when these are grafted upon resistant species.

Mosaic of potatoes.

Studies on potato mosaic at the Louisiana station show that this may reduce the yield from 80 to 95 per cent. Some Canadian strains, especially Spaulding's Rose, are quite resistant. Of five commercial strains, however, only one was good. Smith's strain of Triumph has yielded as high as 200 bushels to the acre. At the Maine station the disease was transmitted by juice inoculation, but only to a slight extent by contact of plants. It was found to be much easier to transmit it by plant lice and artificial mutilation than by contact of diseased plants or by flea beetles. In its control, roguing was found to be partly effective, if early, frequent, and complete, and early harvesting was quite so. Imported stocks were found to be good if from hill-selected or rogued stock from aphid-free regions or from healthy isolated fields. The principal agent in the transmission of the disease appears to be the pink and green aphis, the primary host of which is found to be the rose, and it is believed that a partial control of the disease, at least, may be secured by eliminating this host. It is therefore recommended that rose bushes in the vicinity of commercial potato fields, especially where certified stock is grown, should be removed or annually deaphidized. The disease was found in all commercial varieties in the State except Irish Cobbler. Varieties

were found to vary in resistance from none to nearly entire. Control by spraying was found to be difficult and expensive. Curly dwarf in Rural New Yorker was found to be due to a virus that produces mosaic when transferred to Green Mountain. "Streak" was found to be similar or related to mosaic.

Other potato diseases.

At the Nebraska station relative humidity is found to play an important rôle in determining the progress of tuber rots, there being a gradual increase in the amount of rotting corresponding to an increase in relative humidity. The North Dakota station reports that not all discolorations of the vascular ring are due to fungi. The common cause of wilt in the State is *Fusarium oxysporium* var. *longius*, and the chief cause of dry rot is *F. discolor* var. *sulphureum*, which gains entrance through wounds and follows the attack of wilt. Tests at the Oregon station show that the planting of a nonsusceptible crop in diseased soil for only one year is not sufficient to free the soil of Verticillium wilt.

In studies of potato wart, at the Pennsylvania station, a number of untested American varieties were found to be immune. Immunity appears to be an inherited character and can be imparted by either parent. In treating potato seed for black scurf, at the Iowa station, hot formaldehyde was found to be as effective for control as either mercuric chlorid or cold formaldehyle, and the rapidity of treatment by this method makes it available for large quantities of seed. By using formaldehyde of double strength and increasing the temperature, a treatment of two minutes instead of several hours was found to be sufficient and resulted in no injury to the seed.

At the Maine station leaf roll, net necrosis, and spindling sprout were found to be very commonly associated, as if caused by the same agency. Studies on the leaf roll at the station show that it can be transmitted both by grafts and plant lice, but inoculation of the juice did not transmit it. For its control, hill selection and roguing, which should be done a little later than for mosaic, were partly effective.

Investigations by the Idaho station on the calico disease of potatoes show this to be carried in the seed and apparently not to be infectious. It reduces the yield about 20 per cent. The causal organism of "streak" or russet dwarf disease was not isolated, and it is believed it may be a type of mosaic. It is transmitted in the field from plant to plant and infection has been secured by rubbing the juice of infected plants on the stalks of healthy plants.

From studies at the Vermont station it is believed that tip burn of potatoes may manifest itself as a physiological disease, due to loss of water from the hydathode pores and the consequent death of the marginal vein running under these. The hydathodes are grouped around the tip of the leaf where the disease first shows itself. At the Iowa station the physical character of the soil, moisture conditions, and shading are all found to be negative factors. The young hoppers are most injurious, the adults doing but little injury. The burning action is believed to be due to a toxin.

Several strains of potato Rhizoctonia have been isolated at the Utah station, which vary in their pathogenicity on different hosts. Some which appear identical in cultures vary widely in their ability

to infect host plants. Treatment of the tubers with corrosive sublimate decreased the amount of disease and increased yields. The Montana station finds that blackleg is largely a question of soil moisture, and where irrigation is held down the tubers remain sound and there is very little soft rot. It was not found to hold over in the soil.

At the Texas station, in spraying potatoes with Bordeaux mixture for late blight and scab, reducing the pressure from 180 pounds to 90 pounds per square inch reduced the protection one-half. Three nozzles per row gave much better protection than two nozzles. Bordeaux, 4–4–50, was the most efficient formula. This station also states that an organism has been persistently isolated from the storage rot of Irish potatoes that resembles *Fusarium oxysporium*, which may be a new species or a variety of the orgamism.

Tests at the Mississippi station on sweet potato black rot show that by bedding a rotten tuber infection practically always results, even in uninfected soil, indicating that all rotten material should be thrown out when bedding.

Fusarium wilt of potatoes has been investigated at the Nebraska station. This disease shows a difference in symptoms under dry land and irrigated conditions, the progress of the disease being much more rapid in the presence of high soil temperatures and moisture. There was practically no infection below 24° C. There appear to be three different types of infection, one coming from the seed piece, another from the stem and roots, and a third from the soil through the seed piece, the latter being the most common in irrigated sections.

In general, seed treatment at the Arkansas station for the control of potato scab was not found profitable for that State, due to the general acidity of the soils.

Sugar-beet diseases.

At the Utah station the dry-rot canker of sugar beets was found to be caused by a strain of *Corticium vagum* of the potato. Its effect on the sugar beet is severe, causing a dry rot and a damping-off of the seedlings. It does not appear to be seed borne. Late blight and root rot are also serious troubles, destroying all the foliage and the tap root of the affected beet succumbing to a black rot. The exact cause has not been clearly established; but a number of fungi have been associated with the destruction of the rootlets, which is the beginning of the disease, including *Phoma betæ*, *C. vagum*, *Pythium debaryanum*, and various Fusaria, but the decay of the tap root seems to be due to *Phoma betæ*. It is intimately associated with climatic fluctuations and is intensified by conditions which tend to lessen the vitality of the beet.

The Colorado station reports that the early stages of the rot of steckling sugar beets show as an internal rotting, from which various organisms have been obtained, all of which will cause the disease. When the beets attain considerable size and maturity they appear to be immune. Stecklings are low in sugar and very susceptible to disease. Late plantings and early harvesting tend to reduce the disease.

At the California station it has been demontsrated that the leaf hopper is not a mechanical transmitter of curly top of the sugar

beet, but that an incubation period of about five hours in the body of the insect is necessary before the disease can be transmitted. A combined incubation period of two days in the leaf hopper and the beet is required, after which the disease shows itself in the beet in about five days. No disease was produced when either single insects or masses were fed for five minutes on diseased beets and then immediately transferred to sound beets. All attempts to transfer the disease by mechanical means, such as transfer of juices, contact of diseased material, or through soil infection, failed. Where there is an average of four or five hoppers to the beet the crop is almost certain to be a total failure. There is no evidence that it is a seed-borne disease. The leaf hopper overwinters in the red-stemmed Alfilaria in the foothills of the lower part of the San Joaquin Valley, from whence it migrates northward as the season advances. Strong nicotin dust has been found to destroy the hoppers, but earliness and timeliness of application are important factors in its control.

Tobacco diseases.

Tests at the Virginia station of the disinfection of tobacco seed for angular leaf spot show that this can be accomplished by treatment with 2 per cent formaldehyde or with a 1:1,000 mercury bichlorid solution for 15 minutes, although this injures the seed slightly and delays germination a little. On untreated plats there was 25 per cent infection, the treated plats being entirely free. It may be carried over in the cloth cover of the seed beds and also in the soil. Boiling the cloth covers for 10 minutes gives complete disinfection, and if tobacco is fall plowed the carrying over in the soil is not so great. The Kentucky station finds indications that both this disease and wildfire are seed borne, and may be partially controlled by bagging the seed heads to prevent seed-pod infection. Wildfire is found by the Wisconsin station to develop most markedly between 82° and 91° F., although it could infect its host at a temperature as low as 59° F. and as high as 98° F. A relatively cold soil favors the disease and a warm soil reduces it.

At the Massachusetts station successful inoculations have been made of the wildfire organism (*Bacterium tabacum*) on the petunia and tomato, indicating that these plants may be possible hosts. For its control, the station recommends sterilization of the soil of the seed beds, seed disinfection with formaldehyde, and sterilization of the cloth covers used on the seed beds. Lime sulphur and sulphur dust did not give very good control, better results being obtained with fresh Bordeaux mixture, either as dust or spray.

The Connecticut State station emphasizes the fact that soil sterilization alone is not sufficient. If the disease appears in the field, control measures must be carried out early, best by the destruction of infected plants and removal of all infected leaves. Spraying is not believed to be practicable in the field and may injure the quality of the leaves.

The North Carolina station reports that infection of "speck" of tobacco comes through the seed and soil. It is recommended to use new cloth for covering each year, and to use disease-free seed.

Wheat rusts.

Studies at the Indiana station have shown that there are at least six biologic forms of rust in wheat. The cereal leaf rust is believed

to be an introduced disease, but closely related to wild-grass rust. It is probably carried over in the cereal and does not require an alternate host. The Minnesota station finds at least 33 distinct forms of stem rust of wheat which can be distinguished from one another by their action on different varieties. It is believed that the spores may be wind-borne and travel hundreds of miles. Spores were collected in spore traps with an airplane at an elevation of 1,650 feet. Urediniospores do not commonly live during the winter and the rust comes largely from infected barberries. The fact that these spores do not live over winter is confirmed by the Nebraska station. Orange leaf rust, however, was found on a number of cereals throughout the winter. The Montana station reports that that State has the most complete eradication of barberry of any State, and no stem rust appeared the past year, although leaf and glume rust was present.

Smut in wheat.

At the Washington station a count of smut spores on the seed of numerous samples of wheat from various sources showed a variation from 0 to 20,176 per grain. In the crops grown from these samples, the maximum percentage of smut was 20, while a considerable number of plantings remained smut free, even though the spore counts per seed were high. Numerous samples showing from 100 to 500 spores per grain remained smut free, indicating that a large percentage of the smut on the seed had lost its infective power; and the conclusion is reached that such resistant varieties as Marquis, when seeded in the spring, will rarely have sufficient smut to justify the expense of seed treatment. In a series of tests with artifical infection of the seed, varying from a few hundred spores per grain to a maximum of 278,000, the percentage of smutting in the crop was generally higher than in similar degrees of smutting of farm infected samples. As a result, it is possible to predict from microscopic analysis the probable percentage of smut which will appear in spring seedings, when disinfection is omitted, and to indicate when disinfection may be omitted. From a test of various seed treatments, the conclusion is reached that copper carbonate dust, at the rate of 2 ounces per bushel of seed, is as effective as any other treatment, including formaldehyde or bluestone, is more convenient to use, and is less injurious to the seed.

The California station also reports that very good success has resulted from treatment with dry copper sulphate or carbonate, the latter being slightly better.

The Idaho station found a relationship between the soil moisture from the time of seeding until the plants appeared above ground and the amount of infection with bunt upon the crop at harvesting time. The amount of bunt infection increased as the amount of moisture increased, and the highest infection developed at the lowest temperatures. Experiments showed that the infection can not live in soils that are continuously wet and that cultivation has an effect in reducing the amount of infection.

Wheat scab.

Studies at the Missouri station on the tolerance to acid conditions of the organism causing wheat scab (*Gibberella saubinetii*) show

that it has a wide range of tolerance of H-ion concentrations, and that conidial production markedly increases as the H-ion concentration increases.

The Wisconsin station found in investigations on the influence of climate on wheat scab, that wheats blight most in a comparatively warm soil, above 53° F., while corn blights most in a cool soil, below 68° F. Wheat and corn seedlings are attacked by the parasite only when under unfavorable environmental conditions as to temperature, moisture, soil reaction, or otherwise, or a combination of these factors. These results emphasize the value and explain the reason for planting spring wheat at the earliest safe date in the spring, winter wheat at the latest safe date in the fall, and corn only after the soil has warmed up in the spring. The station has been quite successful in selecting and breeding strains resistant to scab, based on individuals showing a marked freedom from "open" anthers.

The North Dakota station reports that there appear to be two phases of scab, a seedling blight and a head blight. In the seedling form (Fusarium) the fungus is rarely found above the first node above the diseased roots, and the organism does not travel up the stem. In the head form (scab) it only goes about an inch below the glumes. The embryo is attacked before the endosperm. It was found that formaldehyde treatment does not fully reach the inside of plump grains. Hot-water treatment was an effective means of control, reducing the disease to less than 1 per cent. The disease is much like Helminthosporium, and is not systemic.

Other cereal diseases.

The Tennessee station reported the appearance of downy mildew of wheat in the State for the first time. Studies on the foot rot of wheat, at the Washington station, have as yet not resulted in the isolation of the casual organism. The disease was first found in the State in 1919 and was severe in at least 40 per cent of the winter wheat in the Spokane Valley, often necessitating cutting the crop for hay and frequently reducing the yield from 30 to 50 per cent.

At the Minnesota station it was found that sandy soils and high moisture content are favorable factors for the development of Helminthosporium on wheat and barley. Investigations at the Tennessee station show that the external infection of wheat seed is heavy, mainly with a Helminthosporium or an Alternaria, or both, and very commonly with a wheat scab fungus, a Fusarium. Internally the seed was contaminated only to a slight extent, mostly with the scab fungus. Loose smut was perfectly controlled by the hot-water treatment, but not by formaldehyde. No treatment had any noticeable effect on wheat-root rot. The treatments apparently had no effect on the yield. Scab fungi were also often present in the root system of young seedlings, the damping-off fungus, Pythium, being of common occurrence. All of the above organisms cause root rot, and wheat deterioration is due to these as well as to scab and leaf and stem rusts.

The Iowa station has shown that the European buckthorn (*Rhamnus cathartica*) is the only alternate host of the crown rust of oats in Iowa, and aids the spread of crown rust very materially early in the season. The loss can be eliminated by eradication of the alternate host.

The Washington station finds resistance to oat smut to be heritable and in general to follow Mendel's law, although it is made up of multiple factors. Resistance appears to be dominant in oats and susceptibility dominant in wheat.

The California station has found a leaf scald of barley, due to *Rhynchosporium* sp., to be rather prevalent, especially on early barley.

Bean diseases.

Studies of bean rust at the Virginia station indicate that marrow and red or red mottled beans are most resistant, while most white beans and those of pea shape are susceptible. Two biologic strains of the causal organism were found, one on kidney beans and one on black-eyed cowpeas, either of which does not attack the other host. The Minnesota station has isolated at least two biologic forms of the fungus of bean anthracnose. The Michigan station finds that the organism causing bean mosaic is filterable and is apparently disseminated by insects. The use of 2-year-old seed proved an efficient remedy for the control of bacterial disease of beans.

Diseases of peas.

The Maryland station isolated several organisms from the root rot of peas, among them species of Fusarium, Ascochyta, and several bacteria. Tests of resistant varieties promise means of control, and the Delaware station emphasizes the benefits of rotation for this purpose. The Utah station has also found a number of organisms, including *Corticium vagum*, Pythium, and various species of Fusaria, and reports that it also occurs in the sweet pea.

Cabbage club root.

The Wisconsin station finds that club root of cabbage develops through a wide range of temperature, but that it is checked when the moisture is held at a point below one-half the water-holding capacity of the soil. Avoidance of poorly drained land for cabbage culture is therefore important in controlling the disease. At the Rhode Island station club root did not appear until the fourth year on heavily limed plats (10,500 pounds per acre), and was then much less than on the unlimed plats. Among the improved varieties of cabbage at the Iowa station, Iowa No. 5 has proved to be resistant to yellows and of a good typical Copenhagen type.

Tomato diseases.

Studies on the Fusarium wilt of tomatoes at the Georgia station have included tests for immunity of many cultivated and wild varieties, but without success, immunity being only relative. There is apparently no real immunity. The Louisiana station reports that the wilt of tomatoes, caused by *Fusarium lycopersici*, is a southern and warm climate disease, growing best at 29° C. Selections for resistance are quite promising.

The Tennessee station finds indications of three distinct strains of *Fusarium* of the section *elegans* among the tomato-wilt fungi. At the Texas station it was found that *F. lycopersici* is carried in every part of the plant, roots, stems, petioles, leaves, calyx, and fruit.

Cultures made from tomato plants, affected with blight, at the Washington station, showed in many cases both Rhizoctonia and

Fusaria, which indicate that there may be a relation between these two fungi in the production of the disease. At the West Virginia station it was found that the potato Phytophthora can be cultivated on tomato fruit, and then inoculated into the tomato plant without apparently increasing in virulence. Good results have been obtained in the control of late blight and also of leaf spot by spraying with Bordeaux.

At the Indiana station infections from the bacterial leaf spot of the tomato have been made on the pepper and potato and also on buffalo bur, bittersweet, matrimony vine, henbane, and wild tobacco. The causal organism has survived 16 months' drying on tomato seed and appears to live over winter in the field in the trash from diseased plants. This station obtained no evidence of seed transmission of tomato mosaic. Many weeds have been found to be hosts, especially the horse nettle and the clammy, smooth, and Virginia ground cherry.

The Tennessee station finds tomato buckeye to be widely distributed over the State, and that the same organism, a Phytophthora, causes a rot on rhubarb. Spraying with Bordeaux mixture readily controlled Cercospora and Alternaria leaf spots, and had no effect on the early ripening of the fruit. Fusarium wilt appeared to be carried by the seed.

Other vegetable diseases.

The Massachusetts station finds that carrot blight is not a bacterial disease but is due to a fungus, Macrosporium. Eggplant blight studies at the Louisiana station show this to be caused by *Phomopsis vexans*. It reduces the yield in the State fully one-half. It is carried over winter in and on the seed, and seed and soil treatment, with spraying with fungicides, when properly done, will check it, but it is questionable whether this would be practicable. It has not been possible to secure disease-free seed.

Downy mildew of lettuce is found by the Iowa station to occur on both wild and cultivated plants. Wild lettuce is often a source of infection. It is primarily a seedling disease, and Bordeaux mixture gives efficient control if applied at this stage. The Texas station reports that tip burn of lettuce, which is very destructive, is apparently a bacterial disease. An organism has been isolated that resembles one described by the Kansas station. The Massachusetts station finds that lettuce drop is fully controlled by formaldehyde.

Tests at the Oregon station showed very effective protection of seedlings from onion smut by the formaldehyde drip method, when the solution is applied in proper strength and quantity. The Wisconsin station reports that the progress of this disease is facilitated by a cool soil (60° F.), and at temperatures of 84° F. or above it is completely prevented.

The Georgia station finds a number of organisms in the fruit rots of peppers, including several species of Colletotrichum, Glœosporium, Macrosporium, Cytospora, and an unidentified bacterium. The New Mexico station reports that the recommendations to keep the soil moisture not higher than 12 per cent by irrigation, and to use light loamy soils with good drainage is being successfully adopted for the control of chile blight. A strain, Variety 9, has

proved very resistant, and by planting this in connection with proper soil moisture conditions almost complete control is secured.

At the Pennsylvania station two distinct species of Phytophthora, including several strains, were found to be associated with the crown rot of rhubarb.

At the Michigan station, passing Fusaria through the tomato was found to weaken it and rob it of its power to digest starch.

Pink sauerkraut, which was giving considerable trouble in Wisconsin, was found by that station to be due to the growth of certain yeasts, and was dependent upon the amount of salt used, the amount of acid, the temperature, and the oxygen supply.

Studies at the Texas station showed that stem-end rot of watermelons is due to *Diplodia tubericola*, which causes the Java black rot of sweet potatoes, and can be readily carried from one host to the other; therefore, the two crops should not follow one another, as is often done in Texas. The station also found that watermelon anthracnose is caused by *Colletotrichum lagenarium*, and that this organism also readily infects cucumbers, cantaloupes, squashes, gourds, and citron.

Forest diseases.

The Minnesota station reports that the removal of all currant and gooseberry bushes within 200 to 300 yards will protect pines from the white pine blister rust under usual conditions. At the Utah station a severe disease of the poplar (*Populus bolleana*) was found to be due to a Cytospora. This especially affects trees headed back or severely pruned, so that it is thought that this practice must be abandoned. American varieties of sycamore were found to be very susceptible to a disease of the leaves and twigs, due to *Gnomonia veneta*. European varieties are more or less resistant. The Arizona station reports a disease of the pepper tree, due to a species of Trametes, which produces swellings and knots on the trunk and branches and a rather soft rot of the wood. This is found to spread quickly through the trunk and requires careful attention to pruning and the protection of wounds.

Miscellaneous plant diseases.

Studies at the Montana station show that sunflower wilt is apparently due to a Sclerotina that causes damping-off and occurs mostly on land that has been in wheat. The North Carolina station has found a new bacterial disease of the soy bean, caused by an unidentified species of Phoma, which lives over winter and affects the pods and stem.

The Arkansas station is studying a bacterial disease of foxgrass. Inoculation experiments show that the organism is capable of infecting all common cereals except rice.

The New York State station has found a new species of fungus, *Septoria callistephi*, causing a leaf blight of the aster.

In a plant disease survey of the State, made by the Arkansas station, three new diseases were found, a Septoria glume blotch of wheat, a Phoma disease of cotton, and a Phoma on plums. The glume disease has been reported in Europe.

Seed treatment.

In studies of the action of formaldehyde on tobacco seedlings at the Massachusetts station, solutions of 1:1,000, which is the

strength usually used in watering the plants in transplanting, were found to be toxic, although in the greenhouse no toxic effect was noted with a strength of 1:750. No concentration has yet been found that will affect Thielavia without injuring the plant.

In treating wheat seed with formaldehyde the Oregon station found that the formaldehyde was absorbed by the grain and apparently retarded enzym activity as well as checked the respiratory processes. It has a retarding effect on germination and a spindling effect on seedlings, but its action varies with temperature, barometric pressure, etc.

ENTOMOLOGY AND ZOOLOGY.

Bees.

At the Minnesota station it was found that bees can be successfully pedigreed. Mating usually occurs between 2 and 5 p. m., and by keeping the bees in the dark for 5 days and bringing them out about 5 p. m., selected matings can be secured. Studies of the habits of bees, at the Iowa station, have brought out some interesting facts. A bee starting to gather honey from one particular kind of flower will ignore all others, and if the honey flow stops in that kind of flower it goes out no more for the day. Only in exceptional cases were nectar carriers found to change, even temporarily, to carrying pollen upon the cessation of the nectar flow for the remainder of the day, except in the case of those gathering nectar and pollen from the same plant. They were found to carry from 50 to 75 to 85 per cent of their own weight of pollen and as many as 30 trips may be made in a day. The time required for a trip for nectar varied with the abundance of the flow, from 15 minutes to 1 hour. Trips for pollen were often completed in five minutes. The usual interval spent in the hive between trips was three minutes. On an average a bee flies at the rate of about 10 miles an hour when going to the field and 15 miles an hour when returning to the hive, but can fly at the rate of 20 miles an hour with a load in a calm. They were frequently noted as traveling about a mile in three minutes unloaded and in four minutes loaded, if the wind was not blowing.

At the Kansas station bee colonies protected by a windbreak wintered much better than unprotected ones and the two-story hive gave much better results than the one story. Bees need protection even more during an open winter than during a severe one. At the South Carolina station dry sawdust packing proved an excellent winter protection, using 4-inch layers at the sides and 6 inches on top.

The Oklahoma station reports that annual sweet clover has proved to be superior as a honey plant to the biennial varieties, as the flow can be prolonged by early and late plantings. In studies at the Washington station on the poisoning of bees in orchards that have been sprayed, especially where alfalfa is grown, an attempt has been made to incorporate a repellent in the spray. Nicotin, naphthalene, and lime-sulphur proved quite effective. The loss which often results from spraying is a serious one to the orchardist as well as the beekeeper, as it interferes with the natural pollination.

Fruit insects.

The New York State station finds that the apple red bug is susceptible to dusting mixtures containing 1 or 2 per cent of nicotin.

At the Ohio station the use of miscible oil at the time of dormant spraying is found to be efficient for the control of the red spider in apple orchards.

The Oregon station reports that a combination of lime sulphur, 1 to 12, with 2–100 oil is very efficient in controlling the pear-leaf blister mite, and the pear thrips was effectively controlled by spraying with miscible oils or whale-oil soap and nicotin sulphate at the New York State station. Experiments at this station confirm early indications that the pear sinuate borer is susceptible to treatments with arsenical poisons.

Lead arsenate in the "pink" spray was efficient in controlling fruit worms of the pear at the Oregon station.

For the control of the apple and peach tree borer, experiments at the West Virginia station show that spring and fall applications of miscible oils, scraping the soil from around the trunk, applying the remedy, and replacing the soil, gives the best results, being 90 per cent efficient. Paradichlor-benzol may be used, but there is a little more danger to the tree. Both the Missouri and New Jersey stations report excellent results from the use of paradichlor-benzol, the latter station showing that this will kill 95 per cent of the borers in trees 6 years old or older in fall treatments, with no injury to the tree. The Maryland station finds, however, that this material severely injures young trees. Pine tar creosote did not cause injury to young trees, and if applied with proper reference to the time of egg laying is quite effective.

The New York State station reports that at least three species of plant bugs breeding on hickory and oak are causal agents of serious deformations of peaches.

Studies made at the Florida station on plant bugs and their injuries to citrus and other trees, as well as to truck crops, show that tobacco and sunflowers are favorite hosts, which suggests a method of control by planting these as trap crops.

At the Kentucky station three species of destructive leafhoppers have been found upon the grape, which cause a mottling of the leaf and are very destructive. They produce two broods a year. The Iowa station reports that by the removal of pruning rubbish from vineyards the grape cane borer can be almost entirely eliminated.

For the control of leaf rollers on the apple and pear the Oregon station recommends miscible oil, lime, and glue as an efficient mixture to kill the eggs. This is confirmed by results at the Montana station, which reports that many orchards were saved by its use. The Washington station finds that these insects are remarkably resistant to standard sprays.

Strawberry insects.

Observations at the Tennessee station indicate that the strawberry weevil works on several unrecorded food plants of economic importance. It is found to cut the buds of the apple and breed in them. The newly emerged weevils also cut the buds of tomato and cotton but do not breed in them. A mixture of 85 parts of sulphur and 15 of lead arsenate is recommended for its control. In the South it attacks new beds mainly, while in the North it is most injurious in

old beds. At the Arkansas station this weevil is found to lay eggs also on the blackberry, dewberry, and raspberry. The strawberry variety Aroma was found to be quite immune to its attacks. The Tennessee station finds the strawberry crown borer to be very destructive, preventing the formation of runners. The eggs are laid the latter part of March and plantings before April 1 from selected plants, free from the borer, are quite safe if at least 25 rods away from old plantings, since the insect can not fly, which simplifies its control. Old beds should be plowed under. Studies of the strawberry root louse show that egg laying begins November 17 and continues to January 1, hatching about the middle of February. It has not yet done serious injury.

Codling moth.

Codling moth studies at the Massachusetts station show that 100 per cent of the early larvæ pupate at once and produce a summer generation, those coming later make cocoons and winter over. At the California station this insect was found to attack the walnut as well as the apple and to be readily transferred from one to the other. Spraying or dusting with lead arsenate gave as good results on the walnut as on the apple. At the Missouri station the largest percentage of clean fruit was obtained by using 100 pounds pressure and the disk and Bordeaux nozzles, and the smallest percentage with the spray given with 250 pounds pressure. Moderate pressures have consistently given higher results than high pressures. More worms entered at the side of the fruit than at the stem or calyx ends.

At the New Mexico station there are believed to be four full broods of the codling moth in that State. Late spraying is believed to be essential there, as 75 per cent of the infestations occur through the side of the fruit. The so-called calyx spray is less important, the second and third broods being the most important and these usually come after July 1. In the pear spraying schedule, the calyx and first brood spray can be combined, reducing the expense without decreasing the efficiency.

At the Washington station calcium arsenate was inferior to lead arsenate and magnesium arsenate was still less efficient in controlling the codling moth. Rod and clipper nozzles gave better results than the spray gun. The use of laundry soap as a spreader was not of much advantage.

San José scale.

Reports from the Washington station show that the San José scale responds to the usual insecticides very differently in different localities, and that the actual strength of spray is not the only factor involved. Dry polysulphids were not as efficient as the ordinary liquid lime sulphur. Oil sprays were more rapid in action than sulphid sprays. At the Texas station commercial sulphur products as dormant sprays were very successful for the control of this insect. Successful control on nursery stock was secured at the Missouri station by dipping in a solution of miscible oil of a strength of 1 gallon of oil to 12 to 15 of water, this treatment killing 99 to 100 per cent of the scales.

Mexican bean beetle.

Extensive studies on the life history of the Mexican bean beetle, at the Alabama station, show this to be somewhat different in the South from what it is in its western habitat. Emergence from hibernation begins early in March and the first eggs are deposited about March 21. In Alabama it is found to be active, in some degree, during every month in the year. Breeding begins in March and a complete generation is produced before the beetle is supposed to emerge from hibernation in the West. Development is also more rapid, a record of 28 days from egg deposition to the adult stage having been obtained, and reproduction continued steadily until all food supply was destroyed by frost, resulting in probably four or five generations. The food habits also appear to be undergoing a readjustment, as it attacks cowpeas, which it had not previously touched in the West, as well as soy beans and all varieties of table beans, navy beans being particularly susceptible. There is evidence of very extensive early dispersal of hibernating adults, amounting to more than 75 miles in some cases. Only one parasite has been found, which is rare, and birds do not touch the beetle.

The New Mexico station reports that in the southern part of the State the broods so overlap that distinctions can not be made. This year they were noted as early as May 28 in Torrance County and May 15 in Dona Ana County. They are found to lay eggs on six or seven different varieties of weeds, not necessarily legumes. Active adults and pupating larvæ were taken as late as September 28 in the Mesilla Valley. The Colorado station reports good results in the control of this insect with arsenite of zinc, this giving better results than arsenate of lead. A single spraying controlled the insect fairly well in that State and did little injury to the foliage.

Corn ear worm.

Studies on the corn ear worm at the West Virginia station show that the first brood is small and scattering. The second one is larger and more regular and is responsible for most of the injury to early sweet corn and tomatoes. The third brood is large and more coherent than the earlier broods, and is not sharply distinguished from the fourth brood which appears late in September and is apparently incomplete and is wanting in some years. There is much overlapping of broods. The third brood feeds on the late sweet corn and field corn. It is most abundant for 10 to 14 days from about August 22 to September 7. Silage corn planted to mature and harvest by the middle of September suffers less than if planted later. In control by dusting, the dust must be placed on the silk to be efficient. Spraying with lead arsenate and tobacco extract was found to kill the eggs. In a comparison of dusting and spraying, the latter gave 25 to 30 per cent better control, cost less, and was easier to apply. At the Missouri station on a plat sprayed with lead arsenate there was 4.77 per cent damage, on one dusted with lead arsenate 9.88 per cent, and on check plats with no treatment 12.2 per cent.

Corn root worm.

Tests at the Louisiana station of planting date to escape the southern corn root or budworm resulted in the March planting being badly infested, but in no injury to the April and May plantings. All methods of seed treatment were ineffective.

Cotton boll weevil.

In hibernation studies at the South Carolina station of 1,000 weevils placed in cages 12 per cent hibernated successfully and came out alive in the spring, the majority coming out during April, and all were out by June 1. The Georgia station reports that dusting with calcium arsenate just about paid for the cost of treatment.

The Alabama station has studied weather conditions as affecting weevil injury. If sufficiently hot and dry for a period of more than a month, especially during the first part of the fruiting season, the weevils may be naturally controlled so fully that dusting will not be needed or will not pay. While it may appear to be inadvisable to dust in periods of frequent rains, it is believed that every effort should be made to continue dusting at the usual four or five day intervals, in spite of threatening weather, as there is no natural control at such times and the weevils multiply with great rapidity. As the margin of profit per acre decreases there must be a prospect of higher yield to justify dusting. In tests made at the station the profit from dusting in most cases increased rapidly as the margin of yield increased above half a bale per acre.

The Texas station reports an increase of fully 30 per cent of the cotton crop when lead arsenate was properly applied for the control of the boll weevil. At the Mississippi station parasites of this insect were found to vary much in different localities, from none to 50 per cent. Calcium arsenate, both as dust and spray as well as mixed with molasses and applied by hand, when properly applied, controlled the weevils to such an extent that paying results were obtained when cotton was grown on land fertile enough to make a half bale or more to the acre without weevil damage. It was found that the pink boll worm is readily killed at a temperature of 125 to 130° F., and cotton seed will stand temperatures of 175 to 180° F. for several hours.

Thurberia boll worm.

At the Arizona station it was found that the larvæ of the Thurberia boll worm will feed on tame cotton, but it has been impossible to get eggs deposited on that plant. The life history of *Thurberiphaga catalina* has been worked out and it has been found that the larvæ will complete their development on cultivated cotton.

Leafhoppers and tipburn.

At the West Virginia station quantitative tests of infection of potatoes with tipburn by leafhoppers indicate that this may be accomplished by a single hopper. It is believed the trouble may also be due to other causes. Excellent results in control were obtained at the Iowa station by spraying three times with Bordeaux mixture. Tests showed that it is the toxicity of the Bordeaux mixture to the nymphs and its repellent action on the adults that affords effective protection. It was found that Bordeaux mixture does not prevent tipburn by its action on the leaf, but rather by its action on the insect. At the Wisconsin station spraying with Bordeaux mixture upon both top and under side of the leaves controlled the leafhopper and the following tipburn. Unmistakable symptoms of hopperburn were found in a muskmelon field, and a large number of adults and nymphs of the hopper were found on the leaves, indicating that this is apparently also a host plant.

Tobacco insects.

Studies of the tobacco flea beetle at the North Carolina station show that a strip 18 inches wide around the seed beds will keep the insect out. Dusting with lead arsenate has been successful and is claimed to have saved from $25 to $30 per acre. At the Wisconsin station the northern tobacco worm was effectually controlled by a dust application of one part of lead arsenate with eight parts of air-slaked lime, or a spray of 2 pounds of lead arsenate to 50 gallons of water.

Cabbage maggot.

The New York State station finds that corrosive sublimate of standard dilutions is destructive to the eggs and young larvæ of the cabbage maggot and will not hurt plants with a well-established root system. Similar studies at the Indiana station also showed the effectiveness of this material, used in two applications, 1 ounce to 10 gallons of water, or a 1 per cent dust mixture of the sublimate with gypsum or hydrated lime. One treatment with the liquid was effective in controlling the maggot on the radish. Tests at the New Hampshire station showed a marked efficiency of a tobacco dust and lime mixture, composed of equal parts of each. This is found to have a direct insecticidal effect upon the egg. On treated plants the larvæ did not reach the roots for several days after the untreated ones, which is a distinct advantage to the plant. Egg laying on the treated plants was very much reduced, but rains removed the protection.

Grasshoppers and crickets.

Studies in grasshopper control by the Montana station show that these insects feed mainly from 8 to 11 a. m., and poisoned bait should be put out at this time. A bait composed of bran, molasses, white arsenic, and salt, with or without amyl acetate, gave practically a clean-up. The wet method of mixing the bait was found preferable, there being less poisoning and irritation of the worker's arms. The Wisconsin station also reports the above mixture far superior to all others.

At the South Dakota station crickets were found to cast their skins from 9 to 11 times. Ordinarily there is only one brood a year, but some years there may be two matings. Nearly 50 per cent of the eggs were found to be parasitized, and a new parasite was reared. Crickets cause much injury to alfalfa, for the control of which disking in the fall or deep plowing is recommended.

Field and truck crop insects.

The Kansas station reports that the pea louse has been found on alfalfa, causing at times a loss of 25 per cent of the first crop. The clover-leaf weevil was also found to cause considerable damage to alfalfa. The Colorado station finds that arsenate sprays, if properly applied, will control the alfalfa weevil.

Studies on the cowpea weevil at the North Carolina station show that this insect appears to be changing its habits and is working more on the soy bean, which is replacing the cowpea as a crop in the State. The Oklahoma station finds that the cowpea louse winters on Euonymus and *Ilex decidua*. Paradichlorbenzene was efficient in controlling it.

The Missouri station finds that marked diminution in chinch-bug infestation has resulted from systematic cleaning up and burning of all waste. It is estimated that the loss caused by this insect in that State in 1920 was $15,000,000.

Tests at the Texas station show that fumigation of the tubers for the control of the sweet-potato weevil was not satisfactory, cultural methods being more promising.

Investigations at the Maine station show that the sole overwintering host of the potato aphis *Macrosiphum solanifolii* is the wild rose, and the prevalence of this insect on potatoes in the Aroostook region depends directly upon the prevalence and proximity of the wild rose in the vicinity of the fields.

The Massachusetts station reports success in trapping the flies of the onion maggot, if this is done at the time of egg laying, the maggots being very much reduced by this means. The striped cucumber beetle was successfully controlled at the Indiana station with a dust mixture of one part of calcium arsenate to 20 parts of gypsum.

The Wisconsin station reports that the serious losses caused by the pea moth may be reduced from 25 per cent to 2 or 3 per cent by planting early varieties as early in the spring as the soil will permit and refraining from planting peas on or near the same field two years in succession. New plantings should be at least one-fourth mile away from the previous year's plantings.

Miscellaneous insects.

Several species of June beetles are found by the Kansas station to have a 1-year life cycle, instead of two or three years as previously reported. The Mississippi station finds that May beetles do considerable damage to pecan trees, and 20 species have been found on them, some being new to the State. The hickory-bark beetle is also a potential pecan insect.

The Maryland station secured satisfactory control of the boxwood leaf miner with nicotin solutions to which molasses was added. At the New Hampshire station tests of tobacco dust diluted with lime for the control of root maggots showed that dry applications killed the larvæ, while infusions were ineffective. Rain reduces the efficiency of the treatment. This mixture was found to be of value both as an insecticide and as a repellent.

The Utah station reports a new species of moth seriously attacking sagebrush, also a new species of parasite.

The pale western cutworm is reported by the Montana station as a very serious pest in that State. Methods of control have not been very successful, but a bait of poisoned fermenting molasses has considerably reduced its prevalence. It is estimated that last year it destroyed $5,000,000 worth of crops.

The Kentucky station finds two species of white fly attacking plants in the greenhouse. One, *Aleyrodes vaporariorum*, may produce a brood in about 20 days. It can produce young without mating, but in this case all are males. A second introduced species enters the greenhouse in the fall. The adults are readily killed with fumigants, but as the eggs are not affected several fumigations are necessary.

The chrysanthemum midge was effectively controlled at the Maryland station by early spring spraying with nicotin solutions about the time the slips are taken. Most of the injury is done during the cool weather of the spring and fall.

The Kentucky station reports that paradichlorbenzol is an excellent remedy for clothes moths, carpet beetles, ants, etc. The Mediterranean flour moth was successfully eliminated from mills by fumigating with hydrocyanic acid at the North Carolina station.

The Massachusetts station found the Indian-meal moth to be the cause of trouble in a candy factory, infesting the boxes of packed candy and being found after these were delivered to stores. The moth was brought in on nuts. It was completely controlled by fumigating the nuts and screening the packing rooms.

Tests at the Oklahoma station show the great vitality of the stick-tight flea. One individual lived over two years and seven months and another over three years without feeding. The Oregon station finds that earwigs can be very effectively controlled with sodium fluorid with bran, molasses, and other carriers.

Moisture and temperature effect on insect life.

In studies on insect activity as affected by moisture and temperature, at the South Carolina station, it is found that the rate of metabolism is directly correlated with the convergence of the temperature and moisture, temperature being the dominant factor. From 58° to 90° F. are the temperature limits for metabolism, and from 40 to 68 per cent the moisture limits. Parasites are controlled by the same laws. The maximum control by parasites can therefore be quite accurately predicted from climatic conditions.

Parasites.

The Mississippi station has found two new parasites of the southern grass worm, which are very effective in its control, one being a bee fly and the other a disease known as "polyhedral disease." The North Carolina station finds that of the mountain pasture insects there are 10 or 12 species that are important, taking more from the pasture than does grazing. It is believed that grazing with sheep at the time the eggs are deposited may control them.

The South Dakota station finds that parasites control from 30 to 60 per cent of the wheat-stem maggot. Fall planting of trap crops and the fall destruction of wild hosts, volunteer rice, barley, etc., are recommended.

The New York Cornell station has reared and successfully introduced a newly discovered parasite of the woolly aphis. At the Texas station 54 generations of *Aphis gossypii* have been bred without the appearance of any males, indicating that asexual reproduction is the rule with this species.

Insecticides.

The West Virginia station has been engaged in a study of the possibility of insect control by impregnating the host plant with poison. In experiments on the wild apple, a strength of 1:1,000 potassium cyanid killed the tree, 1:10,000 either killed or injured the tree severely, 1:25,000 did much injury, but 1:100,000 did no injury. The woolly aphis was killed by all strengths below 1:100,000, although there was an area around the roots where the

aphids were not killed. In experiments on the wild cherry, aphids were killed with 1:100,000 with some possible injury to the plant.

At the New Jersey station, 0.0002 gram per liter of hydrocyanic acid was found to give perfect control of greenhouse insects, at 40° to 100° F., in closed vessels. A dosage of $\frac{5}{6}$ ounce per 1,000 cubic feet gives a density of 0.0003 gram per liter.

In studies of the immunity of insects to insecticides at the Washington station no progressive immunity of the San José scale to oil sprays was noted, but there was a local partial immunity, fluctuating from year to year.

At the Ohio station an outbreak of the catalpa sphinx was successfuly controlled by dusting from an airplane, a hopper being attached to the side of the cockpit, and dry undiluted lead acetate used. The aviator flew close to the ground, the wind and current of the propeller disseminating the powder widely over a field of 6 acres. The grove was passed over several times, less than a minute being required, and it is estimated that 99 per cent of the caterpillars were killed.

The Oregon station finds that by the use of caseinate as a spreader, it is possible because of the more even spread to reduce the lead arsenate in sprays of this material one-half with equally good results.

Nematodes.

The Oregon station reports finding nematodes on alfalfa for the first time in this country, and that they were artificially transferred to clover. A method of testing for their presence has been devised by the Alabama station, which can be carried out in two weeks, based on growing summer squash which is very susceptible to them. By means of this test it can be determined how long it is necessary to fallow in order to eradicate the nematodes.

Crawfish.

Investigations at the Mississippi station showed a 98 per cent efficiency in the extermination of crawfish with carbon disulphid on small areas. Two poisonings were necessary. Tile drainage helps in control, and should be combined with poisoning. Three species have been studied, one probably new. These vary largely in their breeding habits, producing from 16 to 500 young, some requiring open water, while others do not.

ANIMAL NUTRITION.

Nutritive requirements.

At the Connecticut State station rats fed a ration in which fat is a minimal contamination quadrupled their weight in the usual time and appeared as well nourished as rats with a liberal amount of fat in their diets. It is assumed that pure fats are not an essential part of the maintenance diet. In a similar test with a diet containing only an exceedingly small amount of carbohydrates the rats grew from an early age to adult size at a rate rarely exceeded on normal rations. A chemical analysis of the bodies of these rats showed that they contained practically as much glycogen as rats fed a diet containing abundant carbohydrates, indicating that the rat can build its tissue carbohydrates from noncarbohydrate material and can get the necessary energy from other sources than carbohydrates.

At the Missouri station a biochemical study of the squab and mature pigeon in regard to protein storage showed the former to have a 75 per cent higher lipoid and a 15 per cent lower protein content than the latter. The lecithin content of the squab was greater and the total protein content about 10 per cent less soluble and contained relatively less albumin, globulin, amino acids, and extractive matter, but relatively more proteose, peptone, and peptid nitrogen. A determination of the maintenance requirements with different planes of nutrition showed this to vary. With a lot receiving a liberal ration, this was 5,777 therms daily per 1,000 pounds, with a more restricted ration 4,869 therms, and with a still lower ration 4,408 therms. Holstein heifers did better on the low plane than did Jerseys. There was little relation between the protein plane and growth in height, but a close relation with increase in weight.

The Illinois station finds that for maintenance there is not much difference between the vegetable proteins, but for growth the animal proteins are found to be of a materially higher value than those from vegetable sources. Tests at the New York Cornell station indicate that the protein of coconut oil meal has a higher growth producing value than that of corn meal, and lower than that of rice bran or wheat middlings.

Studies at the Kansas station confirm the fact that none of the short-chain fatty acids in the food are deposited in the body fat, but that the unsaturated fatty acids of the food are so deposited, thus causing the body fat to have a low melting point. The results also indicate that body fat produced by a high protein diet contains more of the unsaturated fatty acids and has a lower melting point than that produced by a low protein diet. In experiments at the Oklahoma station it was found that with a 6-months-old pig and a year-old pig, on the same feed, the fat of the older animal had a considerably higher melting point.

Experiments with swine at the Wisconsin station indicate that roughage may not be necessary for the health of these animals if the rations contain all the necessary nutrients and vitamins. Pigs fed grain alone with no roughage get stiff, but when this is supplemented with dirt or charcoal they give little indication of stiffness with the former, although more with the latter. A stiff pig weighing 250 pounds rapidly recovered and gained up to 350 pounds when cod-liver oil was given.

Nitrogen equilibrium could not be maintained with high-producing cows on a ration of clover hay and silage with corn, oats, and barley, but with alfalfa hay it could be maintained. Corn stover and timothy hay, grown on very acid soils, showed a very low lime content, indicating that if these were used as the only roughage with breeding animals they would produce bad results. Although there is some popular prejudice against the use of barley as the only grain for breeding cattle, entirely satisfactory results were obtained by its use.

Vitamins.

At the Connecticut State station rats fed a diet deficient in both fat and carbohydrates, consisting of 90 per cent protein and 5 per cent inorganic salts with a small daily dose of vitamins in dried alfalfa and brewery yeast, have grown at more than normal rate up to 225 grams weight, but subsequent growth has been much slower.

Trials with variable quantities of vitamin B in rations otherwise identical showed a quantitative relationship between the amount of vitamins fed and the gain in weight. Ophthalmia appeared only in rats deprived of the fat-soluble vitamin, but never in those weakened by other disease or defect of diet, showing it to be purely a food-deficiency disease and not infectious. Rats have been grown from early age to full adult size on dried whole milk powder, cornstarch, and lard, indicating that dried milk powder is not necessarily deficient in vitamins.

In extensive studies on vitamins made at the Wisconsin station, whole milk was found to be very rich in fat-soluble vitamin as compared with its content of water-soluble vitamin. Two cubic centimeters a day of whole milk was sufficient to produce normal growth in rats fed white corn, while it required 16 cubic centimeters per day to supply enough water-soluble vitamin for a rat to grow normally. There was no decrease in vitamin on heating milk under 15 pounds pressure at 120° C. for an hour. In centrifugal skim milk the amount of fat-soluble vitamin is only one-tenth or less of that in whole milk, and therefore the so-called "filled milk" (evaporated skim milk to which coconut oil has been added) is so deficient in fat-soluble vitamin that it would not sustain normal growth in rats even when liberal amounts were supplied. Results obtained at the Minnesota station do not support the theory of a chemical relationship between soluble vitamin and plant carotinoids.

In studies at this station on the distribution of antiscorbutic vitamin, it was found that 1 gram per day of green forage from oats, alfalfa, corn, or timothy will provide enough of this vitamin to protect a guinea pig from scurvy, while it takes 1½ grams of cabbage or 3 grams of rutabagas or turnips. Potatoes, being much lower in this vitamin, from 5 to 10 grams are needed. Ten grams of yellow carrots are required and 20 to 30 grams of sugar beets, sugar mangels, or table beets. Fat-soluble vitamin is found to be quite stable, as it can be boiled with quite dilute acids or alkalis or treated with hydrogen or oxygen in acid or alkaline solutions with little or no loss, but under certain conditions oxygen destroys it quite readily. It is also destroyed to some extent by the rays of the sun, from which, however, it is protected in plants by the chlorophyll. In hays, bleaching the chlorophyll by rain or over exposure to the weather results in a loss of the vitamin.

The antiscorbutic vitamin is much less stable than the fat-soluble vitamin. Certain types of fermentation destroy it; others do not. It is absent in silage and roots, and vegetables stored over winter are less potent in antiscorbutic properties in the spring than when fresh. It is soluble in water, alcohol, ether, chloroform, or acetone, and is destroyed by oxidation by hydrogen peroxid or potassium permanganate.

Four-weeks-old puppies fed a basal ration low in fat-soluble vitamin, consisting of rolled oats, white corn meal, skim milk, salt, and a little calcium phosphate, developed rickets in six to eight weeks, but with the addition of 5 grams of cod-liver oil they became normal in 10 days. One lot of poultry fed white corn and casein gave an egg production of 108 for the first month and 19 the second, with a loss of 80 per cent of the chickens. A second lot fed the same

ration with an addition of pork liver (rich in fat-soluble vitamin) laid 117 eggs the first month and 107 the second, with a loss of only 10 per cent of the chickens. The addition of cod-liver oil to the ration of the first lot brought it up equal to the second lot.

A definite relation is found between yellow coloring matter and fat-soluble vitamin content, yellow corn containing more than white, deeper colored butter fats more than light colored, and light colored beef fats less than higher colored. A similar condition is found in egg yolks produced under ordinary conditions, those richest in yellow color being richest in fat-soluble vitamin, but it is possible to produce a light colored yolk very rich in this vitamin by the use of pork-liver or cod-liver oil. As far as is now known, white corn is as good as yellow for horses, dairy cattle, beef cattle, and sheep if they are fed ordinary well-balanced rations, including plenty of good green-colored hay. This is not true for hogs.

It is found that dogs on a ration low in fat-soluble vitamin suffer from the same eye disease (Xerophthalmia) as rats.

The theory that there is a vitamin that controls or affects the ability of animals to assimilate and use the lime in their foods has received confirmation. Fresh green forages apparently contain this vitamin. There is still a possibility, however, whether this ability to increase lime assimilation may not be due to fat-soluble vitamin. Experiments show that a ration low in lime may be safely used as the only roughage for a part of the gestation period, but not during the last three of four months, when the most growth occurs in the fetus. Animals fed straw as a roughage all through pregnancy aborted or produced dead or weak offsprings. When cows were fed during the first seven months of gestation on clover hay and oat grain, and the hay was then replaced by oat straw, they produced normal calves, but if the substitution of the straw was made two months earlier the calves were premature, undersized, and died. This trouble was corrected by the addition of legume hay, which is rich in lime. Goats on a mixture of grains and oat straw gradually went into a negative calcium balance, but when put on pasture for 10 days again started to store calcium. Further tests along this line with goats showed that with the addition of cod-liver oil they quickly went into a positive calcium balance again.

In nutrition studies at the Minnesota station it was found that certain indol derivatives have antiscorbutic properties. The antiscorbutic properties of milk are destroyed quite readily by oxidation, while heat alone has little or no effect, even in an atmosphere of carbon dioxid. In the presence of oxidizing agents the antiscorbutic properties are destroyed slowly at room temperatures and the speed of oxidation is increased by heat. This was also found to be true of the antiscorbutic properties of orange juice. The antiscorbutic property of cows' milk fluctuates with the vitamin content of the food eaten by the cow. In the spring the milk is superior in nutritive and antiscorbutic properties to that produced during the winter months on dry feeds. Summer milk is better than spring milk. It is found that summer butter that has been stored for several months loses its fat-soluble vitamin rapidly upon exposure. Tests show that diets low in protein and water-soluble vitamin B cause atrophy of the testes and hypertrophy of the

adrenals, and when the vitamin is omitted the effect is more pronounced than when the percentage of protein is low.

At the New York State station the first noticeable effect in poultry in vitamin starvation (a polished rice diet) was a loss of appetite, the food consumption falling to a low amount. There was a continuous loss of weight and egg production ceased immediately. In from six to eight weeks active symptoms of polyneuritis appeared, resulting finally in more or less complete paralysis. In vitamin starvation the animal was unable to utilize in the normal manner a diet consisting of carbohydrates.

Experiments carried on at the Iowa station show that rabbits have a larger vitamin A requirement than rats or swine, indicating the possibility of further differences of omnivora and herbivora. At the Kansas station, eggs from hens receiving a vitamin-free diet when fed to rats greatly retarded their growth. The North Dakota station has secured some evidence that sprouted grain will prevent scurvy.

Experiments at the Wisconsin station show that chicks and pigeons require much more water-soluble vitamin than rats, the latter requiring only 2 per cent, while the former require about 12 per cent and also require about 10 per cent or more of butter fat to provide sufficient fat-soluble vitamin, and even then they may develop leg weakness and friability of the bones, indicating some factor necessary for chick growth and development that is not so essential in mammals.

The Washington station found that a satisfactory growth could not be maintained with rats on wheat, and there was no reproduction, but this was overcome by adding 0.29 to 0.35 per cent of soda to the ration. Growth and reproduction were normal when the wheat ration was supplemented by protein and fat-soluble A vitamin, if a proper adjustment of the inorganic elements, calcium, chlorin, and sodium was made.

Digestibility studies.

The Texas station finds considerable variation in the digestibility of pentosans from different sources. The nitrogen-free materials other than pentosans, starches, and sugars are less digestible than these. In concentrated feeding stuffs these three constituents account for nearly all of the nitrogen-free extract, but not in the coarser feeds.

Tests were made at the North Dakota station of the digestibility of prairie-grass hay. In samples cut in the spring, at the height of the growing season, and at maturity, that cut at the height of the growing period gave the highest coefficients of digestibility, was more readily eaten, and was apparently more palatable. Little difference was noted between the hay cut in the fall at maturity and that left uncut to weather over in the winter.

Acidity of rations.

At the Iowa station swine were fed a basal ration with an addition of as much as 300 cubic centimeters of normal sulphuric acid per day. There was no marked evidence of ill effect on the carcass, the fat, or the mineral content of the bones. There was a slight decrease from normal in the alkali reserve of the blood. No ill effects

were noted in the second generation. With rabbits, the progeny of acid-fed parents made normal growth. A highly acid ration was fed to rats for three generations with normal growth and reproduction.

ANIMAL HUSBANDRY.

Effect of age on gain.

In studies on the effect of age on gain of beef cattle, at the Nebraska station, the youngest cattle proved the most economical in cost of gains. At the end of a 200-day period the average daily gain was 2.21 pounds for the 2-year-olds, 2.21 pounds for the yearlings, and 2 pounds for the calves. The feed required for 100 pounds of gain was 619.46, 515.84, and 458 pounds, respectively. The calves made as much gain from 77.5 pounds of feed as did the 2-year-olds from 100 pounds or the yearlings from 86 pounds.

Silage feeding.

A summary of three feeding experiments at the Kentucky station, comparing corn and sorghum silage, shows that the corn silage steers gained an average of 0.24 pound more per day than the sorghum silage steers; the cost of producing 100 pounds of beef was $2.71 greater in the sorghum silage lot; the selling price of the corn silage steers was 12 cents per hundredweight greater; an acre of sorghum silage and supplementary feeds produced 36.4 per cent more beef than did an acre of corn silage and supplementary feeds; and the cost of producing an acre of corn silage was $42 as compared with $57 for an acre of sorghum silage. All factors considered, the sorghum silage was only 92.2 per cent as economical as is corn silage for beef production. At the Indiana station feeding trials showed no appreciable difference between silage from corn, and soy beans grown together and corn alone, either with or without cottonseed meal as a supplement.

At the Mississippi station the cheapest gains were made on corn silage and cottonseed meal. The greatest gains were made when a liberal ration of corn was fed, but this also proved the most expensive.

At the Wyoming station sunflower silage produced a little less gain than oat and pea silage. The largest and cheapest gains were made with native hay and cottonseed meal.

At the Oklahoma station sheep readily ate silage made from broom corn stalks with the heads removed. Digestion trials showed that it was equal in feeding value to silage made from other grain sorghums. The Montana station believes that failure of sunflower silage to cure satisfactorily in some localities to be due to its low sugar content, irrigated plants being exceptionally low in sugar. Mannitol is found in sunflower silage in large quantities, reaching a maximum and then diminishing until it largely disappears.

White versus yellow corn.

Studies on the nutritive value of yellow corn, at the Nebraska station, indicated a deficiency of ash constituents. Supplementing with 5 per cent of a complete ash mixture improved the ration so as to enable very slow but persistent growth. It is deficient in quality

and quantity of protein. The addition of more corn protein as corn gluten did not markedly improve the ration, but the addition of 15 per cent purified casein improved it quite decidedly. Supplementing with certain other proteins, such as egg albumin and gelatin, lowered rather than raised the efficiency of the ration, perhaps due to the sticky physical character of the supplement. The fat-soluble vitamin did not seem to be a limiting factor, for the addition of butter fat to a ration of yellow corn, casein, and ash did not improve but rather lowered the efficiency. Green feeds were found to be valuable additions to a ration for growing chicks. In comparisons of the nutritive value of white and yellow corn for growing chicks, better results were secured in all cases with yellow corn.

In feeding results at the Wisconsin station yellow corn produced decidedly larger and more economical gains than white corn when fed to pigs not on pasture, with such supplements as skim milk, whey, or linseed meal. For pigs on good pasture there was very little difference. With two lots of common feeder pigs, one fed a mixture of yellow corn and tankage and the other white corn and tankage, both in the self-feeder, the former gained 1.06 pounds per day and the latter 0.63 pound. Those on yellow corn required 447 pounds of the ration for each 100 pounds of gain, while those on the white corn required 554 pounds. Similar results were obtained when skim milk was substituted for the tankage. The results indicate that white corn should not be used for feeding pigs in winter in the dry lot but should only be used for feeding pigs on summer pasture, or for other stock. At the Kansas station also gains were made on yellow corn at a less cost than on white corn, and similar results were also obtained with sheep.

Wool.

Shearing tests at the Texas station show that shearing twice a year produced about 1 pound more wool per annum than one shearing and the sheep made 2 pounds more gain per head, but the indications are that, taking the extra cost into consideration, the advantage, if any, is small. The Montana station finds that feed has a considerable effect on the weight of fleece, length of fiber, and amount of grease, and probably on the strength and elasticity of the fiber.

Wool investigations at the Wyoming station show that exposure to the weather is destructive and is more injurious to the strength than is alkali, if the latter is dry. Open fleeces suffer most from weathering, owing to exposure. A study of the various materials that make up the impurities of unwashed wool, suint, sand, and dust, and ether soluble materials, showed that suint is more sensitive to moisture changes than the fiber itself, and a wool high in suint is more hygroscopic. The fat has about the same hygroscopic properties as the fiber, the inorganic materials having least. Studies on the change in moisture and weight when wool is brought indoors from outside, and vice versa, show this to be roughly proportional to the surface area. It is more rapid at first and diminishes until an equilibrium is reached.

Feeding trials with hogs.

The South Carolina station reports that in a study of protein supplements for hogs, fish meal proved to be slightly superior to tankage and contains more mineral matter. The Pennsylvania sta-

tion also finds fish meal to be an economical and efficient source of protein as a supplement to corn, oil meal not being so satisfactory. Semisolid buttermilk made lower gains and required a greater amount of feed to produce 100 pounds. Pigs fed in dry lot made lower gains than those on forage. At the Washington station no marked difference was found between fish meal containing 56 per cent of protein and tankage containing 60 per cent. Coconut meal was found to be bulky and somewhat unsatisfactory as a protein supplement, especially in rations for young pigs. In similar studies at the Indiana station, fish meal proved fully equal to or slightly better than tankage. Soy bean oil meal was practically equal to tankage, while ground soy beans were not as efficient and were unpalatable. Buttermilk proved the most efficient of the supplements tested, semisolid buttermilk being less so.

At the Nebraska station tankage proved to be a more economical protein supplement than shorts, increasing the rate and economy of gain. On an average, 24.56 pounds of semisolid buttermilk replaced 12.67 pounds of tankage and 33.28 pounds of corn.

In feeding tests carried on at the Missouri station, lots were fed sunflower seed alone, with different amounts of corn, and with corn alone, compared with a check lot on corn and tankage. The lot fed on corn alone proved better than the lot fed on sunflower seed alone. Equal parts of sunflower seed and corn proved to be the best combination and compared favorably with the usual Corn Belt ration of corn and tankage. While the gain from sunflower seed alone was fairly satisfactory, the pork was decidedly soft.

The Oregon station finds molasses to be a satisfactory substitute for barley, up to 40 per cent, being fed mixed with grain in the self-feeder. Coconut meal supplemented with tankage was found to replace barley, up to 25 per cent, and was a little cheaper. At the Kansas station the value of alfalfa as a supplement to corn and tankage or kafir and tankage was demonstrated, and after feeding this for three generations the lot receiving this combination was the best.

In experiments at the Vermont station, pigs carried from birth up to four or more times their original weight on normal milk, evaporated milk, powdered milk, and reconstructed milk, gave the best results with whole milk powder, this being better than normal whole milk. Reconstructed milk gave the least satisfactory results.

Tests of feeding mesquite beans to swine, at the New Mexico station, showed that 140 pounds of the beans were equivalent to 100 pounds of grain. Tornillo beans showed a good feeding value but must be ground.

Results obtained at the Alabama station show that when velvet beans are fed to brood sows they do not produce good litters, the pigs being weak; the sows had very little milk and the pigs died within a week. When fed to growing pigs these failed to grow and fatten.

Forage crops for hogs.

At the Pennsylvania station rape alone proved superior to rape and oats, or rape, oats, and peas grown together, and gave forage for a longer period. The North Dakota station finds great economic

advantage in using pasture crops for hogs in the State, and that March-farrowed pigs secure much more value from pasture during the season than May-farrowed litters.

The Oklahoma station reports very satisfactory gains of 1.55 pounds daily for 60 days with amber cane, which was only exceeded by corn and barley. Oats proved of low feeding value for hogs. Darso and kafir were found to have about 95 per cent the feeding value of corn. In all tests ground grain gave better results than whole grain.

Forage-crop tests at the Mississippi station showed the largest daily gain from a lot grazed on soy beans and corn, growing together, this being 1.56 pounds. The Virginia station reports that in a comparison of hogs on forage only with those receiving corn and tankage in the self-feeder, the former were cheaper to raise, but those receiving the supplement came on the market earlier and brought a better price. The most economical method is to supply hogs on pasture about 50 per cent of the concentrated feed which they would require if they were not on pasture.

At the Kentucky station hogging down corn alone produced 401 pounds of pork per acre, with $28.72 net profit. By supplementing this with tankage, self-fed, 535 pounds of pork were produced with a net profit of $36.05 per acre. Hogging down corn and soy beans grown together produced 347 pounds of pork, with a net profit of $19.41 per acre. By hogging down soy beans alone, supplemented with 2.5 per cent of the body weight of corn per day, 846 pounds of pork was produced per acre with a net profit of $16.72. Hogging down soy beans alone, supplemented with corn in the self-feeder, there were produced 1,114 pounds of pork per acre, but with a loss of $6.01.

At the Missouri station hogging down corn and soy beans, with and without supplements, showed that the feeding of tankage in a self-feeder to hogs on corn materially increases the rate as well as the economy of gain, and that when soy beans are planted with the corn they will not completely take the place of the tankage, an acre of corn pastured off with hogs producing more pork if tankage is fed in addition than will an acre of corn and soy beans hogged down without additional supplement.

Soft pork studies.

Extensive investigations on soft pork have been carried on by a number of the southern stations, partly in cooperation with the United States Department of Agriculture. At the Florida station tests of the fat of live hogs, before putting them on a softening ration, showed considerable individual variation in the melting point. This difference is also shown in the way in which individuals soften and harden on different feeds. Ordinarily six weeks on corn will harden up a soft hog. The rate of gain has nothing to do with the amount of softening. It is believed that internal parasites may play a part in causing the condition.

At the Kentucky station it was found that soy beans will produce a soft pork, but were not as bad in this respect as peanuts. They tend to darken the carcass as well as soften it. The Mississippi station reports that the average daily gain on peanuts alone was 1.29 pounds, and when these were grazed, with grain, 1.47 pounds.

A comparison of the effect of feeding peanut press cake containing practically no oil and whole peanuts at the North Carolina station showed that hogs receiving the whole nuts were more oily, those receiving the press cake being classed as medium.

At the Georgia station it was found that the soft and oily fat of hogs which had been fed on peanuts was not thoroughly hardened after a two months' finishing feed of corn and tankage or cottonseed meal. Classification of the firmness of the carcass by inspection in the cooling room did not consistently agree with the hardness of the fat as indicated by melting point and iodin number determinations. At the Texas station, among lots receiving varying percentages of rice bran in their ration, those receiving as much as 90 per cent were classed as slightly soft.

Poultry feeding.

Inbreeding experiments at the Wisconsin station reached a point, in mating brother and sister, where the eggs did not hatch. Selection on the basis of vigor did not give satisfactory results. At the Missouri station pullets hatched from hens laid 12.6 eggs more per bird than did those hatched from pullets. Other factors favoring high egg production are early hatching, beginning laying early in the season, and early maturity.

Starting at the North Carolina station with a common flock that averaged 89 eggs per hen per year, one lot, mated with common cocks, gave offspring averaging 91 eggs; another lot, mated with pedigreed sires, gave offspring averaging 135 eggs. Cocks from the latter, mated with common pullets, gave a progeny averaging 138 eggs, showing that the improvement came through the sires. Of two brother cocks, one is transmitting high egg production, the other low.

Egg production.

The North Carolina station has observed that hens tend to choose a more basic ration when laying, and when this period is over less mash is eaten, giving the ration a more acid character. At the Oklahoma station wet mash increased egg production in winter, but did not pay when extended beyond March. It is noted that culling by means of external characters should be done soon after the egg-laying period is concluded. After molting has been completed it is difficult to cull in this manner.

The Nebraska station finds that egg size, a character having a distinct commercial value, can be influenced by the proper selection of breeding stock.

Experiments at the Kentucky station show that laying hens whose supply of calcium is limited to that naturally occurring in the food will continue laying eggs until there is a general depletion of magnesium, phosphorus, and calcium in the bones and carcass, and as long as the economy of the hen permits the formation of an egg-shell the contents of the eggs remain quite constant, but with a gradual thinning of the shell. The addition of limestone or oyster shells to the food of such depleted hens increased the egg production 69.4 per cent.

As a result of feeding experiments at the Kentucky station it is found that a low egg production by yearling hens results from a lack

of animal protein in the ration. Protein studies at the Missouri station show that cottonseed meal apparently has a retarding effect on egg production. One pen fed no protein concentrates averaged 39 eggs per hen, while one fed a slight amount of tankage laid 104 eggs. The number of eggs laid varied in proportion to the amount of animal food (tankage) in the mash.

Incubation, hatchability, and vigor.

Incubator studies at the Indiana station show that a temperature of 101 to 102° F. throughout the hatch will give the best results, 100° being too low and 103° too high, the latter being more damaging than low temperatures. The Kansas station finds that the fourteenth and nineteenth days are the critical ones as regards mortality in incubation. Hatchability is found to be affected by feed, one lot fed a standard ration, including green feed, with run of yard, had a hatchability of 62.6 per cent as compared with 8.6 per cent in a lot receiving an inadequate diet, low in water-soluble vitamin B, with no exercise. Examination of a large number of eggs that failed to hatch showed many of these to contain bacteria of the colon group, which were traced back to the hens laying the eggs, indicating the probability of ovarian contamination.

Tests made at the North Carolina station of turning incubator eggs one and five times showed 19 per cent in favor of turning five times. Spraying eggs gave a 10 per cent greater hatch. The Connecticut Storrs station found that hatchability materially increases with the size of the egg. Porous shelled eggs, allowing of more evaporation, give a low hatch.

A study of the factors affecting the vigor of the embryo has been in progress at the West Virginia station. In a comparison of a corn and wheat ration the latter gave a larger egg, and a positive correlation was found between the size of egg and vigor of the embryo. In tests of the effect of confinement, it was found that 2,268 eggs laid by confined hens averaged 66.63 grams in weight and 3,873 eggs from hens on the range averaged 57.94 grams. Twenty-three per cent of the eggs from the confined hens and only 13 per cent from the range hens were infertile. Sprouted oats had no effect on the number, but did have a marked effect on the fertility and hatchability. Green feeds seemed to diminish the weight of the egg about half a gram. In the green-fed lot 18 per cent of the eggs were infertile as compared with 24 per cent of those from hens not receiving green feed.

Feeding chicks.

At the Wisconsin station sweet skim milk proved to be better than sour skim milk or buttermilk. Chicks receiving a basal ration containing skim milk were twice as heavy at the end of three weeks as those on a ration not containing it. Chicks on milk albumin did not do as well as those on meat scrap, and dried buttermilk was not as good as skim milk. Skim milk gave better results than any other animal feed except whole milk. Fish scrap gave gains inferior to beef scrap.

At the Wisconsin station chicks receiving single-grain rations of barley, white corn, or wheat made good growth on all three feeds when 10 per cent of butter fat was added, but below 10 per cent the chicks either died or did not gain. Three lots of laying hens were

fed white corn, one lot receiving in addition skim-milk powder, another lot dried hog liver, and a third lot 1 per cent of cod-liver oil. Health was not maintained on the skim-milk powder, but the other lots did well. The hog liver imparted no color to the eggs.

In investigations at the West Virginia station on the after effect of chick feed, small chicks were fed a low- and a high-protein ration. The low-protein lot laid eggs that were 10 per cent lower in weight, and they were 20 days later in laying the first egg than those receiving the high-protein ration. The first year there was an average of 123 eggs from the high-protein lot and 96 from the low-protein lot. An average of the weights of 7,000 eggs showed a difference of 0.66 per cent in favor of the high-protein lot.

It was found at the Kentucky station that chicks that have once received grit will always retain sufficient in the gizzard, even if they never receive any more, and if hens receive a ration that contains sufficient lime it is not necessary to feed grits.

DAIRYING AND DAIRY FARMING.

Raising dairy calves.

A comparison has been made at the Mississippi station of early and late fall calving, the results now including three years' observations. The early fall calving included dates from August 1 to October 1 and the late fall calving from October 1 to December 30. There was an average difference per year per cow of 683 pounds of milk and 27.5 pounds of butter fat in favor of late fall calving. A comparison of spring and fall calving showed a difference in favor of fall calving. Observations on the cost of raising calves showed that the least expensive gains were made by Ayrshires, next by Holsteins, and next by Jerseys.

At the Iowa station it was found that $109.89 was the cost of feed to raise a calf dropped in winter from birth to first freshening, at which time the weight was 1,010 pounds. Summer calves cost $102.43 and weighed at freshening 941 pounds. Heifers dropped in the winter increased 1,385 per cent in live weight from the date of birth to date of first freshening. There was an increase of 72 per cent in height at the withers, 128 per cent in depth of body at heart girth, and 183 per cent in width at hip bones. Those dropped in summer increased 1,370 per cent in weight, 71 per cent in height, 129 per cent in depth, and 200 per cent in width.

Growth-curve studies at the Missouri station show that the dairy calf passes through two cycles during the extra-uterine period of growth, with maximums at about 5 and 20 months of age. Data obtained indicate also that the calf passes through a cycle in utero, with the maximum at about two months before birth. Growth at a rate approximating normal can be secured by weaning thrifty dairy calves at about 60 days of age.

At the Minnesota station the total feed requirements to raise a dairy calf to 6 months of age, when fed with a minimum amount of milk, is found to be approximately 500 pounds of milk, 450 pounds of grain, and 275 pounds of hay. Animals under 10 months or a year of age require the full amount of nutrients specified by Armsby's standard. Less nutrients are required as the age of the animal advances, until at 18 months apparently about 80 per cent of the

Armsby standard is sufficient. Data secured at the Indiana station indicate that the feed used for calves up to 6 months old has no effect on the vigor of their offspring later.

At the Missouri station Holstein heifers showed a slightly better development than Jerseys on the same protein plane. Very little relation was found to exist between the protein plane and the skeletal growth as indicated by height at withers, but there was a rather definite relation between the protein plane and increase in weight. From the data available it would appear that a 20 per cent plane (20 per cent of total energy from starch) is approximately correct for growing dairy animals, both Holsteins and Jerseys.

At the Arizona station it has been shown that by feeding calves a quart of milk daily after they are 1 month old, and supplementing this with either commercial or homemade calf meal, well-developed calves can be raised. A mixture of three parts corn meal, two parts wheat bran, one part linseed-oil meal, one-half part blood meal, two parts ground bone meal, and three parts of wheat middlings made a very satisfactory ration for young calves as a substitute for milk. At the Washington station dairy calves were successfully raised from the age of 3 weeks up to 4 to 6 months on condensed buttermilk instead of whole milk.

Attempts to raise young dairy calves at the Oregon station wholly on homemade calf meals, consisting of various combinations of mill-run, ground barley, ground red-clover hay, ground oat and vetch hay, oil meal, and soy-bean meal were not successful, and it was necessary to supplement this with milk.

The Montana station reports a comparison of feeding dairy calves a whole-grain mixture of oats, barley, and a little oil meal in a self-feeder with the amount they would eat in 15 minutes hand fed three times a day. The self-fed lot ate more grain, but did not make as good gains as the hand-fed lot, as they evidently ate too much and went off feed for a time.

At the Missouri station the best results were obtained when calves were put on a grain and hay ration at about 60 days of age.

Milk production.

In studies at the Iowa station on individual variation data were obtained on two half-blood full sisters, having a full blood sire, out of a scrub cow, whose average record was 5,258.9 pounds of milk and 233.69 pounds of fat. One of the daughters averaged during her lactations 3,639 pounds of milk and 180.5 pounds of fat, a decrease from her dam's record of 31 per cent in milk and 23 per cent in fat. The other daughter averaged 6,128.4 pounds of milk and 298.33 pounds of fat, an increase over her dam of 17 per cent in milk and 28 per cent in fat. They were under the same conditions of feeding and management.

Studies on the relation of age to milk yield at the Maine station show that this increases up to about 8 years and 3 months and then declines slowly. Butter fat percentage declines slightly from an age of about 2 years to 14 years.

Data secured at the Washington station show that an average cost of producing 100 pounds of milk, delivered at the local plant or shipping point, was $2.88, the cost on different farms ranging from $1.94 to $4.39. Feed constituted 48.31 per cent and man labor 24.2

per cent of the total cost. One hundred pounds of milk was found to require 18.78 pounds of grain, 42.13 pounds of hay, 49.5 pounds of silage, 5.6 pounds of roots or kale, 0.093 month of pasture, and 2.19 hours of man labor.

Comparison of grain feeds.

In a comparison of home-mixed and ready-mixed commercial feeds, at the North Carolina station, the home-mixed feeds proved to be more palatable, cost $22 per ton less, and produced more milk.

In experiments at the Wisconsin station to determine whether dairymen can supply their herds with satisfactory home-grown rations, avoiding the necessity of buying expensive concentrates, it was demonstrated that cows would keep up quite a large flow of milk without losing nitrogen from their bodies if fed an abundance of alfalfa hay, corn silage, and corn. It was found that if barley or oats are fed as the grain, in amounts supplying the same amount of protein, starch must be added to compensate for the lower net energy of these grains. Dairy cattle fed a well-balanced ration of alfalfa hay, corn silage, corn, and oats maintained as good production as on a higher nitrogen ration containing cottonseed and linseed meals.

The North Carolina station has conducted experiments on the effect of cottonseed meal on growth and reproduction. Young animals receiving a ration of half cottonseed meal and half corn silage all became sick, and one died. Another lot receiving somewhat less cottonseed meal and hulls, with cracked oats, became sick, weak, and off feed. Four mature cows receiving over 14 pounds of cottonseed meal daily calved normally, and the calves were at first normal, but after four weeks one became blind and another nearly so.

Feeding experiments at the Iowa station showed that 100 pounds of corn meal was equivalent, for butter-fat production, to 125 pounds of corn-and-cob meal or 140 pounds of ear corn. Very little difference was noted in the value of shelled corn, cracked corn, and corn meal. Ear corn was about 12 per cent less valuable than corn-and-cob meal. Cracked soy beans proved to be worth about 30 per cent more than old-process oil meal for feeding milk cows in connection with corn silage, alfalfa hay, cracked corn, and ground oats.

Experiments at the West Virginia station indicate that soy beans are equal or slightly superior to alfalfa for milk production; and the Missouri station reports that soy beans appear to be better than alfalfa hay as a supplement to a grain mixture of corn chops, 4 parts, with wheat bran and oil meal 1 part each, on account of their apparently greater palatability.

A comparison of velvet bean meal with cottonseed meal, at the North Carolina station, showed that the former is unpalatable, lacks bulk, and produces less milk.

At the Georgia station peanut meal, up to 6 pounds, and whole nuts, up to 4 pounds, were fed with corn silage. The whole nuts appeared to give a harder butter than the meal. No flavor was imparted to the butter.

Tests at the Wisconsin station indicate that hydrolyzed sawdust prepared by treating with weak sulphuric acid under pressure, neutralizing with lime, and centrifuging to remove the calcium sulphate,

may be substituted for corn or barley in the concentrate mixture for high producing dairy cows without affecting the normal milk flow, to the extent of one-fourth to one-third of the concentrate mixture. It is found to be worth about one-half as much as barley in feed for dairy cattle.

Roughage for dairy cows.

At the Virginia station corn silage proved to be the most desirable roughage if supplemented with a good protein-rich concentrate, such as cottonseed meal, soy-bean meal, or linseed meal. At the West Virginia station a comparison of sunflower and corn silage showed that the former did not keep up the milk supply as well as the latter. The Wyoming station reports no significant difference in sunflower silage and oat and pea silage for dairy cows, both being of about equal value in increasing body weight and in the feed cost for producing 100 pounds of milk and 1 pound of butter fat.

The Oregon station reports that sunflower silage produced 100 pounds of fresh milk on less feed than corn or oats and vetch silage, but the amounts consumed did not maintain the body weights, and it was not as palatable as the other silages. It imparted no flavor to the butter. Reports from the Pennsylvania station indicate that sunflower silage is not as palatable as a mixture of sunflower and corn silage and is inferior to a good grade of corn silage for milk and butter fat production.

Results obtained at the North Dakota station indicate that sunflower silage is almost as good as corn silage, although it ranks low in palatability, and that good sweet clover silage is equal to corn silage for milk production.

Red clover was ensiled successfully at the Pennsylvania station and proved to be superior for milk production to a ration in which dry hay alone formed the roughage.

Tests at the Connecticut Storrs station indicate that silage corn varieties which mature there have a higher feeding value pound for pound, than varieties which do not mature, and effect a saving of about 5 pounds of grain for each 100 pounds of milk.

The Minnesota station reports no ill effects from feeding moldy silage to dairy cows. The cows ate the silage freely after becoming accustomed to it.

In a comparison of alfalfa and Sudan hay for dairy cows, at the Arizona station, the cost of milk produced on the alfalfa ration was 14.7 cents per gallon and on the Sudan grass 15.8 cents. The alfalfa lot produced 500 pounds more milk and 20 pounds more butter fat in the four-months' feeding period.

Qualities of milk.

Studies at the Minnesota station lead to the conclusion that milk may be regarded as an emulsion of the oil-in-water type and butter an emulsion of the water-in-oil type. The Wisconsin station finds that some lots of milk at condenseries coagulate to a solid mass, which was formerly thought to be due to acidity, but is found to be apparently due to a disturbance of the balance of calcium salts and the citrates and phosphates. It can often be prevented by the addition of small amounts of sodium citrate or bicarbonate, although

in some cases the latter may be harmful and hasten the coagulation. An excess of any of the normal milk salts, sodium citrate, sodium or potassium phosphate, or calcium chlorid, hastens coagulation. The balance is delicate, but the remedy is simple.

Results obtained at the Minnesota station indicate that what is usually regarded as a change of soluble into insoluble calcium phosphate when milk is pasteurized or boiled is really the coagulation of the colloidal calcium phosphate of the milk. The lower the calcium-ion content of the milk the higher the hydrogen-ion concentration, within a certain range, which is required to produce a normal clot. The colloidal dicalcium phosphate probably does not play a part in rennet coagulation. It is found that abnormal fermentation, occurring occasionally in advanced lactation in individual cows, referred to as "bitter," "rancid," "strong," etc., is the result of lipase action.

The Iowa station finds that the cause of a burnt or caramel flavor in dairy products, thought to be due to overpasteurization, is really due to an organism.

The Connecticut Storrs station reports that in the cleaning of milking machines, immersion of the parts in hot water (180° F.) is the most reliable procedure for all seasons. A continuous stream of water under 55° F., was also effective. Steam proved ineffective and destructive to rubber parts.

In a study of the onion flavor in milk, at the North Carolina station, it was found that by blowing air through such milk for 25 minutes, at a temperature of 140 to 160° F., the flavor could be eliminated, but there is a loss of 15 per cent by evaporation. The flavor is due to the presence of allyl sulphid from wild onions consumed in the pasture and hay. As the wild onion matures the flavor grows less.

Factors influencing fat in milk.

Studies at the Missouri station on factors influencing fat in milk, show a casual relation between temperature and the percentage of fat, there being roughly an increase of about 0.15 per cent of fat for each 10° F. decrease in temperature. This is evidently due to an increased lipoid metabolism in the blood, accompanying the lowering of the temperature with the transformation of blood lipoid into milk fat. When the feed was cut there was a gradual increase in the percentage of fat, reaching a peak on the third day, followed by a drop below average for a few days. Advance of lactation exerts an influence, there being a general decline the second month, followed by a gradual increase during the remainder of the lactation period. During the summer months the fat runs low, but starting with October there is a gradual rise, reaching a peak during December, January, and February. If the cow stands quietly for two hours before milking the successive 100 cubic centimeters are very much like the successive portions drawn from a 1,000 cubic centimeter cylinder after standing two hours, but if the udder is shaken the successive portions are nearly uniform.

Similar results were obtained at the Missouri station, where a study of the milk records of 3,000 Guernsey cows showed a falling off of fat content of the milk during summer and a rise in winter, which was also found to be true of Jerseys and Holsteins. There is also

noted a decline in milk fat during the second month of lactation, followed by a gradual increase during the rest of the period. At the Maine station it was found that the butter fat-percentage secured in the advanced registry tests, as well as the milk yield thus secured, measure quite accurately what the probable yields will be in subsequent lactations.

Bacteria in milk.

The South Carolina station has made a study of the bacterial content of milk. If milk is drawn aseptically there is a retardation of the growth of the bacterial flora for the first 4 hours, but under ordinary conditions there is an increase in 2 hours, which, however, is slower if the milk is kept cool. If aseptically drawn it is sometimes 70 hours before acidity develops. The flora is found to vary somewhat with different animals and includes a number of species.

The Wisconsin station has perfected a simple and rapid method for determining the bacterial content of milk by means of methylene blue reduction.

The New York State station finds that the sanitary condition of the milk-producing farm and the methods of handling are measured by the quality of the milk produced. The quick microscopical test which has been worked out by the station has proved of great value in showing this, and is being put into practical use with satisfactory results.

Butter.

At the Iowa station, in a comparison of butter made by churning sweet and ripened cream, when scored immediately after it had reached the market, the ripened cream butter scored higher in 31 samples out of 40, in 4 samples the sweet cream butter scored higher and in 5 samples it scored the same. After two months in cold storage the ripened cream butter scored highest in 19 out of 42 samples, the sweet cream butter in 17 samples, and the score was the same in 6 samples. After nine months in cold storage the sweet cream butter scored highest in 15 out of 26 samples, the ripened butter in 7, and 4 samples scored the same. The average score in flavor was 35 for the sweet cream butter and 32 for the ripened cream butter. Tests showed that butter made from cream pasteurized at a high temperature does not keep as well over a long period of time as that from a lower temperature. At the Minnesota station, however, it was found that higher pasteurization temperatures, if the cream has a low acidity, results in a better keeping quality of the butter.

At the Connecticut Storrs station a study of the flavor and keeping quality of butter made from sweet cream, from cream with lactic starter, and from cream ripened with *Bacillus acidophilus* and stored for 8 months, showed that the last named had a superior flavor in almost every case.

Experiments at the Wisconsin station showed that when made under the same conditions, whey butter scores as high as and keeps even better than whole milk butter, and the conclusion is reached that nothing in the normal process of making whey butter makes it inferior to whole milk butter. After aging three months, whey butter, scored by 13 judges, averaged a slightly higher score

than creamery butter. Milk butter deteriorated considerably more than whey butter.

Studies at the Massachusetts station on the effect of feed in modifying the chemical and physical characters of butter show that in feeding peanuts, corn, or soy bean oil, there is a marked increase in the formation of oleic acid, linoleic and linolenic acid being transformed into oleic acid. Arachidic acid in peanut oil is apparently transformed into stearic acid.

Experiments in sterilizing butter, at the West Virginia station, show that in order to accomplish this it is necessary to heat the butter high enough to destroy enzyms, but this also destroys the texture of the butter. It can be heated under pressure, however, without producing any objectionable change.

The Michigan station finds the metallic flavor of butter to be caused by certain members of the subtilis group.

Ice-cream making.

Ice cream studies at the Missouri station show that viscosity varies directly with the fat content. The time required to begin freezing increases as the fat content increases. A 14 per cent cream is found to be a little too rich to be entirely satisfactory for the average market, from 8 to 10 or 12 giving by far the best and most easily marketed creams. An increase of overrun results from the use of sugar up to 8 to 12 per cent; beyond this amount there is a decrease. The maximum total solids for a large overrun is found to be 32 per cent. The hardness of the cream begins to decrease when the sugar content falls to about 8 per cent. In general, 12 per cent of sugar is found to be the best quantity for commercial use. In similar studies at the Oklahoma station it was found that 10 per cent of butter fat and 20 per cent of milk solids give an ice cream of satisfactory quality. It was also shown that milk powder or condensed milk gives a firmer and better keeping product, and that milk powder can be used to replace most of the cane sugar and part of the butter fat content.

VETERINARY MEDICINE.

Contagious abortion.

Studies on contagious abortion at the Kentucky station show that the causal organism of this disease is not the same in horses as in cattle. The organism in mares is of the colon-typhoid group, that of cattle belongs to a different group. Jennets were found to absorb the germ or its products from the intestinal tract into the blood stream if the live organism is fed to them, indicating that mares may be infected through ingestion. It is believed that infection comes mainly through the feed. A bacterial vaccine has been prepared for the disease in mares that acts successfully as a preventive for about a year, but is not curative. For cattle, a bacterin is used, followed by a live-germ vaccine, with good success. The same organism that causes the trouble in cattle was found in aborting sows, but after passing through the sow it will not cause abortion in cattle.

At the Connecticut Storrs station cows, heifers, and calves were not infected by virulent cultures of the bacillus given orally in capsules or in milk, but were infected when the cultures were given subcutaneously, interurethrally, or by applications on the surface

of the scarified vulva. Deep vaginal applications only occasionally produced infection. Isolation and disinfection of the cow at the time of abortion, and disinfection of the bull, are effective means of control, although the latter alone is not adequate. The most susceptible time for infection is found to be at sexual maturity.

Tests at the Wisconsin station show that the abortion organisms of bovine origin will not cause pregnant sows to abort, but the organisms of bovine and porcine origin are morphologically and culturally identical, and the blood of infected sows will agglutinate antigens of both bovine and porcine origin. Among a large number of animals vaccinated for this disease, 85.9 per cent had normal calves, while only 68.8 per cent of the calves of unvaccinated animals were normal. None of a number of sows given the bovine strain of the bacillus aborted, while all but one of a number given the swine organism did do so.

Experimental trials, at the Illinois station, to produce abortion in cattle by contact with aborting sows proved negative.

In abortion studies at the Minnesota station the agglutination test was found to be superior to the complement-fixation method for diagnosis. Studies on the cause of sterility show this to be commonly due to certain streptococci combined with *Bacillus pyogenes*, and occasionally colon bacilli and staphylococci are involved. *B. abortus* is probably not only a direct etiological agent, but in many instances may prepare the way for other organisms. Treatment with lysol was of little value. In every case of abortion in mares and of joint-ill in foals, besides the *B. abortus*, a streptococcus was isolated, and cases of joint-ill were cured by injecting antistreptococcus serum.

A study of the after effects of abortion, at the Louisiana station, shows that it may produce orchitis in males and sterility in females, with fat deposits and ossification of the joints. Proper sanitation and isolation of cases are effective means of reducing the trouble.

Investigations at the Missouri station show that as a rule reacting calves apparently have the power to destroy the infection completely before reaching sexual maturity. Unbred heifers do not become reinfected by continuous exposure to nonpregnant reacting cows. The mature female host does not seem to have the power to readily destroy and effectually eliminate the *B. abortus*, but may remain a permanent carrier.

At the Oregon station, in no case has the feeding of infected milk to heifer calves resulted in infection. Breeding negative cows and heifers to negative bulls which had served positive cows did not result in infection. Twenty calves exposed to infected cows in pasture developed two cases. Exposure of pregnant heifers in pens or pasture with cows that have aborted was found to be the chief method of infection, and it may be transmitted in the barn if this is not properly cleaned. The pregnant cow is susceptible, and when fed cultures of the *B. abortus* will become positive and often abort. A milking unbred negative cow placed in a stall where cows had aborted became positive. Animals are most apt to abort during the pregnancy in which the initial infection is obtained. The organism is most readily introduced through the digestive tract, and lives indefinitely in the lactating udder.

At the Arkansas station a number of sows were fed milk heavily infected with the abortion organism from cows through three gesta-

tion periods. Abortion occurred in one case only, and from this case it was impossible to reisolate the organism. Agglutination tests with several of the sows were positive.

Physiological studies, at the California station, show little difference in the organisms isolated from aborting swine and cattle, those from swine, however, being a little more virulent toward guinea pigs. At the Michigan station about 30 strains of the abortion organism have been isolated which do not vary in morphological characters but do in virulence.

At the Kentucky station an examination of the organisms from the reproductive organs of sterile mares show that barrenness is not as common a sequel of contagious abortion in the mare as in cattle. A number of organisms were found, including streptococci in a few cases.

Hog cholera.

Hog cholera exposure experiments have been conducted at the Indiana station to study means of transmission. Healthy pigs in a pen adjacent to one containing cholera-infected pigs, when separated by an incomplete cheesecloth partition, contracted the disease, while with a tight cheesecloth partition they remained well. Healthy hogs in an outdoor pen 4 feet from a pen of infected hogs contracted the disease. After these pens had been vacant four days, susceptible hogs placed in them did not contract the disease.

At the North Dakota station it was demonstrated with two different viruses that hog cholera can be produced by the use of 1/50,000 cubic centimeters, but even this did not establish the minimal dose necessary to produce the disease, but showed that the causative agent propagates within the animal body. Membranes are impervious to the virus, which is thought to indicate its colloidal character and that it has not the property of toxin in solution. It appears to penetrate parchment, such as goldbeaters' skin, but it apparently does this by a process of growth. While it will not dialyze through parchment, goldbeaters' skin, or collodion capsules in artificial media, it will do so when normal hog or horse serum is used as the dialyzing fluid. Neither oxygen gas, distilled water, or acetic acid show any appreciable attenuating influence upon the virus. Precipitation of the globulins of blood serum hog-cholera virus by means of carbon dioxid gas, and of the globulins and albumins by half and complete saturation with ammonium sulphate, failed to remove the causative agent.

The Kentucky station confirms previous reports that the virulence of hog-cholera virus is increased by shaking with glass beads. Organisms from cases of cholera have been successfully grown in a specially prepared medium, which when stained shows chains of cocci-like bacteria.

Studies on the possibility of the transmission of tuberculosis through the injection of hog-cholera serum at the Missouri station show that while tubercle bacilli actually circulate in the blood of tuberculous swine and the disease can be transmitted by inoculation into others, the methods followed in the careful preparation of anti-hog-cholera serum eliminate practically all possibility of such transmission. In regard to secondary infections it is shown that the

organisms of hemorrhagic septicemia, infectious pneumonia, and mixed infections are not primary causes of infectious diseases, but are commonly inhabitants of the alimentary tract and larger air passages, and are not harmful to healthy swine until their resistance is lowered. The proper use of anticholera serum and proper sanitation to prevent worm infection will also prevent complications from secondary infections, and vaccination against the latter is of doubtful value.

Hemorrhagic septicemia.

Investigations at the Kentucky station show that hemorrhagic septicemia occurs only rarely as a primary infection, and rather definite predisposing factors are essential, especially with swine. Pure cultures of the microorganism, when injected into swine, seldom produce the disease, except when a considerable quantity of a highly virulent culture is given intravenously. Subcutaneous, intramuscular, and intratracheal injections and feeding did not produce the disease except in cases where the animal was suffering from some other ailment at the time of the injection, and if the predisposing causes can be controlled, losses from this disease may be materially reduced.

Studies on the pathogenicity of *Bacillus bipolaris* (bovine) at the Nebraska station show that the injection of virulent cultures in normal calves produces only transitory illness, with quick recovery, the illness being mainly characterized by articular disturbances. When the injection is made, however, in connection with a nonfatal anaphylactic reaction, more severe illness and death may result, in which *B. bipolaris* is a determining factor, and repeated injections with autogenous bacterins afford no protection. The apparent proclivity of the organism to localize and cause lesions in bones and joints is a prominent difference between induced and natural infection. Immune serum against *B. bipolaris* can be prepared in the usual manner, and this protects animals against otherwise virulent injections, but the protection is of short duration only. Studies at the Colorado station indicate that a live organism vaccine for this disease is more valuable than one killed by heat or antiseptics.

Tuberculosis.

A case of equine tuberculosis is reported by the Wisconsin station. The disease being rather rare in this animal, it was investigated and proved to be of the bovine type rather than the human or avian. Guinea pigs and rabbits inoculated with bacilli from a pony having the disease contracted it but cockerels did not. The station has perfected a method of preparing a vaccine by killing the organisms with ultra-violet light, which has proved quite successful.

At the California station it was found that about 50 per cent of reacting animals showed no tubercle bacilli in histological studies, but many showed enlarged lymph glands, although cultures from these failed to produce the disease in experimental animals.

At the Illinois station calves inoculated with the avian type of tuberculosis in some cases developed lesions, but no evidence was obtained to show that tuberculosis of poultry is communicable under natural conditions to cattle.

Botulinus.

It has been shown at the Kentucky station that there are two types of *Bacillus botulinus*, A and B. Antitoxin produced for type A will not protect against the toxin of type B, and vice versa; and since it is not known which type is responsible for botulism in any given case it is necessary to use antitoxins protecting against both strains.

The Illinois station reports the practicability of employing chickens for the purpose of differentiating A and B botulinus in food, the positive value being limited to the type A toxin, which, if present, is manifest in a general paresis and coma a few hours after the ingestion of contaminated food. *B. botulinus* has been isolated from several samples of soil, from water of a pond in which fish were dying, from dead fish from an infected pond, from many animal foods and animal secretions, including the milk from an artificially infected cow; also from human foods, including canned string beans and spinach, pimentos, olives, flour, graham and rye breads, and stale ice cream cones, doughnuts, and cakes of various kinds. The spores of some strains appear to be sufficiently resistant to survive the temperature of cooking doughnuts. In some instances proprietary mineral mixtures sold as "tonics" for animals have been found to be contaminated with *B. botulinus*, type A or B.

A sample of corn silage which was causing illness and death of cattle was found to contain the botulinus organism. Animals treated with antitoxin were fed the same silage without ill results. It is thought that a protective toxin for the treatment of botulism can be prepared by injecting increasing doses of the toxin into horses. When A and B toxins are thus used to produce the antitoxin, the reaction is sometimes severe. More consistent results have been obtained by hyperimmunizing horses with only one of the toxins. Botulism in horses, cattle, and swine was traced to feeding flour or stale bakery goods. Viable spores were found in 58 per cent of the flour from local kitchens. The spores develop better at a low than at body temperature.

Anthrax.

The Louisiana station has made extensive studies on anthrax. Investigations on the diagnosis between the true and pseudo-anthrax bacilli show the former are capsuled while the latter are not, and it is fairly safe to diagnose anthrax on this characteristic, but if the capsuled forms are not found it is not safe to conclude that it is not present. Cultural methods do not serve to distinguish them. Non-anthrax forms are motile, but both may grow in chains. The only positive and sure means of diagnosis is by animal inoculation, which takes from 3 to 4 days. Early treatment with antianthrax serum will save 75 per cent of a herd, but the temperatures must be closely watched and the treatment repeated. The infection may be present in the soil, and rainy periods are supposed to cause outbreaks. Soils moistened with water containing the spores and then dried out showed the spores still virulent for guinea pigs. It is also found that the Argentine ant may act as a carrier, and all blood-sucking insects, as flies and mosquitoes, may carry it mechanically, but it does not undergo any phase of its life cycle in them and does not appear to pass through them, except as spores, although the regurgitations are full of bacteria. The bacilli remained virulent for guinea pigs for a

period of 12 years while suspended in lake water. They have remained virulent in milk for a period of 10 years, and for a period of 9 years in dog feces. Negative results from cultures from decomposed blood or flesh are not conclusive evidence for a negative diagnosis.

Necrobacillosis.

The Wyoming station reports that treatment of necrobacillosis by washing the parts with Dakin's solution, containing 10 per cent of potassium permanganate, has been successful if the lesion can be reached. It is thought that the organism lives over in the soil and is transmitted by feed or water. The immunization of rabbits has been successful. Death is found to be due to toxemia. By using a medium of alkaline pyrogallate, which gives anaerobic conditions, the organism can be grown for a few days.

The Montana station reports that necrobacillosis in sheep is apparently associated mainly with management and the weather. It occurs mostly in large bands of sheep, subjected to rough, cold weather and filth.

Swamp fever.

Attempts to pass the virus of swamp fever through hogs have been unsuccessful at the Texas station. Pigs inoculated with the active virus remained healthy, and 21 days after the inoculation blood from these pigs injected subcutaneously into a horse produced no results.

Careful search of the blood of horses which died of the disease failed to demonstrate the spirochaetes claimed by Japanese investigators to be the cause of the disease. Experiments as to its transmission by stable flies have thus far been negative. Inoculations made with serum received from the North Dakota and Wyoming stations were negative, which may indicate that there are biologic strains of the disease.

At the North Dakota station it was found that the virus will dialyze through animal membranes, as parchment and gold beaters' skin, indicating a crystalloidal nature. In artificial media the average incubation period, as noted in 13 years' observation, is from 11 to 13 days, with a minimum of 9 days, excluding one very virulent strain, recently found, which had an incubation period of only 72 to 96 hours. All attempts to inoculate swine with the disease have been unsuccessful.

At the Wyoming station horses were inoculated with filtered and unfiltered nasal secretions from an infected animal. The unfiltered material gave a fever reaction in a few days, which was shown to be swamp fever. The results with the filtered material were not definite. No positive results were obtained by transferring eye secretion of an infected horse to an uninfected one.

Poultry diseases.

The Nebraska station finds that none of the fowl cholera vaccines on the market is of any value. The disease is caused by *B. bipolaris*, the same organism causing hemorrhagic septicemia in cattle and pigs. It is not very easy to produce the disease by inoculation of the organism into cattle, and when successful there is an apparent proclivity of the organism to localize and cause joint trouble. A preventive

serum has been made that is effective against artificial infection, but the protection is of short duration only.

The Rhode Island station finds that in the agglutination test for the diagnosis of white diarrhea the reaction varies with the strain of *Bacterium pullorum* present, and may therefore be unreliable in some cases. *Heterakis papillosa* has been found to aid in producing blackhead. Infection was found to be direct, with no passage through the tissues after the larvæ reach the intestines.

At the Illinois station the examination of a number of cases of limber-neck in poultry showed that there are apparently some types of this trouble which are not related to *Bacillus botulinus*, type A or B. Symptoms of botulism have been produced by feeding certain unidentified, heat resistant, rod-shaped organisms to guinea pigs, and botulinus antitoxin of either type failed to protect against this anaerobe. The Indiana station also reports that in some cases the antitoxin gives no protection. Infection seems to come from eating maggots from decayed flesh. Some cases recover.

The Kansas station reports that satisfactory results have been obtained by the use of chicken roup vaccine in more than 10,000 birds.

Miscellaneous diseases.

The Nevada station has made an exhaustive study of a hemorrhagic disease occurring in cattle. Three anaerobic organisms were isolated from the livers of diseased cattle, viz, *Bacillus welchii*, *B. edematiens*, and *B. botulinus*. The first two are believed to be directly connected with the disease. Cultures of *B. edematiens* reproduced the disease in a much more rapidly developing form than under normal conditions. *B. botulinus* is believed to be a secondary parasite in the disease, there being in typical hemorrhagic disease no paralysis, which is a common symptom of botulinus infections. Emulsions of the organs from autopsied animals failed to produce the disease. It is seasonal in the State, appearing in May or June, increasing to a maximum in late summer, and disappearing in November or December. There appears to be also a dietetic factor in the causation of the disease.

The Louisiana station investigated an outbreak of infectious diarrhea in cattle that occured in the northern part of the State. An organism was isolated and identified as a Prowazekia, which has also been isolated from the soil, human beings, and reptiles. It appears in the winter when the cattle are in poor condition. The life cycle of the organism appears to be completed in about 10 days.

Lymphangitis in cattle is found by the California station to be caused by an acid-alcohol-fast organism. The lesions resemble those of tuberculosis, and a large percentage of cases give a positive reaction to the intradermal tuberculin test. The disease is not mammalian tuberculosis, as it failed to produce a single case of tuberculosis in a large number of inoculations in guinea pigs. A number of cattle reacting to the intradermal tuberculin test showed only enlarged lymphatic skin glands.

The Wisconsin station has successfully used johnin as a diagnostic agent for Johne's disease for the first time in this country. This is difficult to prepare on account of the very slow and uncertain growth of the organism on artificial media.

A study of temperature variations in normal cattle, at the Montana station, showed these to be wider than is ordinarily assumed. Variations of 4 or 5° F. were found in apparently healthy cows.

At the Washington station the hitherto unexplained disease known as "orchard horse disease" is believed to be due to lead arsenate on orchard grass, evidently from spraying, and when feeding of this material was discontinued there was a material lessening in the number of cases. However, horses fed artificially sprayed hay, while they showed typical arsenical poisoning, the symptoms did not fully correspond with those of typical orchard disease. Feeding hay from sprayed orchards gave a typical case and death in one instance. Inoculation from a horse suffering with the disease did not give positive results.

In investigations of swell head of sheep and goats, at the Texas station, no successful remedy has been found, and negative results were secured in all attempts to transmit the disease to healthy animals by the injection of serum, blood, or organ extracts from sick goats. Negative results were also obtained in feeding goats with Saccahuista (*Nolina* sp.), a poisonous plant which has been suspected to be a possible cause of the trouble.

Studies of a bacterial disease of goats, at the Texas station, showed this to be a new disease, infection being largely confined to the gall bladder. Two bacilli were isolated, *B. pyocyaneus* and an organism resembling *B. coli*. Ear mange of goats was found to yield well to a wash composed of sulphur and potassium carbonate.

Parasites.

The Michigan station reports that the period when ox warble flies are on the wing is very short, and if animals are kept in the barn during this period it may offer a means of control.

The Texas station reports that the use of fly traps for the control of the screw-worm fly has been quite efficient and is being widely adopted.

At the Kansas station examination of the stomachs of calves which had died from an unknown cause revealed enormous numbers of minute hair-like parasitic worms, *Ostertagia ostertagi*, sufficient to cause death. This is the second time this parasite has been reported in this country. The Louisiana station also reports a stomach worm in calves, previously reported from South America and Europe, but heretofore not found in the United States.

Studies by the Oklahoma station on the stomach worms of sheep show that the larval worms live longer than is generally claimed, in some cases as much as 16 months. Most of the infection comes from sheep drinking from cattle tracks at the edge of pools, these tracks being found full of worms. A 1 per cent solution of copper sulphate is recommended for treatment, which will remove from 75 to 90 per cent of the worms, and if tobacco dust is added the efficiency is much increased. The treatment is not of much value, however, when the worms have left the stomach and gone to the intestines, where as a rule, however, they are never found in abundance. The Texas station also reports the successful use of copper sulphate as a remedy for stomach worms when the animals have been deprived of food and water for 24 hours before and after administering it. The best

results were obtained with 3 grams of copper sulphate in 100 cubic centimeters of water, but it is believed that this can be reduced to 1 gram with more safety. The dose for sheep should be less than for goats. The Connecticut Storrs station likewise reports tobacco or tobacco extract with copper sulphate as a promising means of control of stomach worms.

Investigations on the lungworms of sheep, at the Oklahoma station, show that the larvae penetrate the intestinal mucosa, enter the lymph or blood streams, and are thus carried through the various organs, finally reaching the lungs. This was confirmed by feeding larvae to a lamb, after which larval worms were found in the blood, lymph glands, and abdominal cavity, but not in the liver or mesentery, indicating its transference by the blood or lymph. The Wyoming station reports that the muscle worm of sheep (*Sarcocystis tenella*) requires no intermediate host, infection taking place directly from sheep to sheep.

The Kentucky station reports that several organisms have been found in the intestinal tract of shoats suffering from infectious necrotic enteritis, many of which are also found in healthy shoats. The constant occurrence of *Trichomonas suis* suggests that this and possibly other protozoan forms are the cause of an acute diarrhea in shoats.

The Michigan station reports that a study of the intestinal protozoa of pigs revealed at least 10 such organisms, some of which are similar to those found in man. Similar studies with poultry also yielded a number of new varieties, some of which are quite common in man.

At the Kansas station conclusive evidence has been secured to show that the tapeworms which gain entrance to the intestines of young chickens are able to remain there after the host matures. Studies of the transmission of the large roundworm (*Ascaridia perspicillum*) show that infection is direct, no intermediate insect or invertebrate being necessary for transmission. The eggs of this parasite pass out with the feces and in two weeks of warm moist conditions attain the infective stage. When such eggs are swallowed by young chicks they become infected. The common housefly is found capable of transmitting two tapeworms, *Davainea cesticillus* and *D. tetragona*.

Experiments at the Minnesota station show that the chick nematode (*Heterakis papillosa*) does not, like Ascaris, pass a part of its early cycle in the lung of the host. Its development is simple and direct, the worms maturing in about a month. None of the recommended disinfectants will render infected ground safe. The eggs will develop to the infective stage in a 1:1,000 solution of mercuric chlorid or in a 1 per cent solution of sulphuric acid. Thorough sanitation is essential and internal treatment of the birds with 1 part chloroform to 20 parts turpentine gave good results.

The Oklahoma station has secured evidence which seems to indicate that if the eggs of the roundworm passed from an infected bird are taken by another they will pass through without hatching. In order to infect they must develop larvæ in the ground, which requires from 10 days to several weeks, depending upon the temperature. Chicks fed the larvæ all died of pneumonia in from 8 to 10 days.

Poisonous plants.

The study of poisonous plants of pastures and ranges has received considerable attention, especially from the stations in the West. At the Wyoming station sheep were put on a patch of the two-grooved milk vetch (*Astragalus bisulcatus*), which is reported to be poisonous, for 50 days with no harmful results. Cattle refused to eat it. It was found that the aconites play a larger rôle in forage poisoning than formerly supposed, causing heavy losses in sheep. It is believed that the toxic principle of the low larkspur (*Delphinium menziesii*) has been isolated. It gives the same kind of alkaloid as the tall larkspur, but not in such large amounts, although it is claimed to be equally as poisonous, the maximum toxicity apparently being in the flowering stage. It is not poisonous to sheep, but is to cattle, of which it is estimated that there was a loss of 60,000 due to poisoning by this plant during the year. Successful antidotes have been prepared. The station has isolated two crystalline alkaloids from a lupine (*Lupinus argenteus*), one of them apparently new. The plant affects sheep mainly. There is no known remedy. The Nevada station, however, reports that all parts of the lupine, at all stages of growth, were fed to sheep without injurious effect. Alcoholic extracts of the milkwort (*Glaux maritima*) were toxic to rabbits, but both the green and cured plants fed to cattle and sheep produced no injurious results at the Wyoming station.

The Montana station finds that white loco, the only poisonous variety, averaged 12,000 to 15,000 plants per acre. One man can clear an acre a day, and the plants do not return.

A study of the toxicity of poisonous range plants, by the Nevada station, showed that quite small amounts of rabbit brush (*Tetradymia glabrata*) fed consecutively for several days has a cumulative effect and finally causes the death of sheep. *Atriplex canescens* and *A. confertifolia* were found to be slowly injurious rather than immediately poisonous, causing polyuria and diarrhea, with a falling off in weight. *A. canescens*, fed in large doses to ewes immediately before lambing, caused abortion. *Halerpestes cymbalaria* contains an irritant poison which may be fatal under certain conditions to both sheep and cattle. *Artemisia spinescens* was negative to both sheep and cattle, as were all local species of lupines.

Arrow grass (*Triglochin maritima*) was found to contain a hydrocyanic glucosid, of which the dried plant yielded 0.25 per cent of its weight. Feeding experiments with the shad scale (*Atriplex canescens*) showed that while it has no toxic effect on cattle it does act injuriously on sheep, causing extreme diarrhea and urination with loss of weight. Analysis shows it to have a high feeding value, but also that it contains two saponins that may be the cause of its injurious action with sheep. It is noted that the poisonous action of many plants appears to vary from year to year, from unknown causes. Their action also varies largely with different animals. Ground squirrels feed extensively on death camas without apparent injury. With the poison hemlock, early growth of the tops was found to be as toxic as the tuberous roots, while late in the season the tops were apparently not toxic. Two species of milkweed, *Asclepias mexicana* and *A. speciosa*, were found to be poisonous.

At the Colorado station the whorled milkweed (*Asclepias galioides*) was found to contain a glucosid and an alkaloid that have not been obtained pure as yet. The plants lost their toxicity with prolonged drying, and after six months it had nearly disappeared. Most of the active principle was found in the leaves, with but little in the stems and flowers. Crude extracts of the dried powdered plant were fatal to guinea pigs, but the partially purified product was not.

At the Mississippi station 5 cubic centimeters of the oil of ergot of Paspalum was fatal to guinea pigs, and the fatty acids derived from it were also toxic. It contains no nitrogen and does not lose its poisonous properties when heated to 200° F.

At the Kansas station a comparison of the trouble known as "corn stalk disease," with anthrax, botulism, hemorrhagic septicemia, and potash poisoning led to the conclusion that it is a definite disease, although the exact cause has not as yet been determined.

AGRICULTURAL ENGINEERING.

Implements and machines.

In tractor tests at the Mississippi station hay was cut on a 9-acre area at a cost of 41 cents per acre, and loaded, without windrowing, at 55 cents per acre.

Investigation at the Missouri station shows that while the draft of plows is materially decreased by disking before plowing, the total amount of work done by disking first is greater than in plowing without disking, in spite of the fact that the draft is greater. Studies at the Iowa station show that the type of bottom on the plow does not materially influence draft. The increase in draft due to speed, which is from less than one-third to about one-half the total draft, within a speed of from 2 to 4 miles per hour, is confined to the draft required for turning and pulverizing. A marsh plow has been devised by the Wisconsin station, using a larger coulter, a heavier frame, a stronger wheel, and longer and higher landslide, which will go through almost any amount of trash and sod without clogging, turning the furrows directly upside down, and practically completely covering the trash and leaving the furrow slices lying flat, in condition for working the seed bed.

At the Iowa station a comparison of round and cutaway harrow blades shows that the latter give a 10 to 20 per cent heavier draft, penetrate more deeply, tend to tear out chunks rather than loosen the surface, are difficult to sharpen, and more easily broken.

A test of limestone spreaders indicated that the most desirable type was that of a trailer behind a loaded wagon, from which the material is shoveled direct to the spreader.

In stump-pulling tests by the Wisconsin station a pull of 20,000 pounds was found to be about the safe limit for a ¾-inch cable, and under most conditions the pieces pulled at this limit were as large as could be economically handled and piled. Experiments with picric acid for land clearing showed it to be much more powerful for stump blasting than any of the ordinary dynamites used, and that 5.5 to 6 ounce cartridges are as effective as 8-ounce cartridges of 20 to 40 per cent dynamite. A 2 per cent moisture content allays dust in cartridges, and with this amount the charges can be de-

tonated with a No. 8 cap. The picric acid is more shattering than low-grade dynamite. It is not affected by temperature, does not freeze, is more resistant to moisture than dynamite containing ammonium nitrate, does not detonate in storage, and is not poisonous.

Fence-post treatment.

Tests at the Minnesota station show that there is little difference between the life of treated and untreated Jack pine fence posts. Treated poplar posts are found to outlast treated Jack pine posts. The Iowa station has demonstrated that quick growing, nondurable Iowa woods can be successfully used for fence posts after having been treated with creosote. For the successful treating of willow posts it is necessary to treat the tops as well as the bottoms. One-fourth inch square twisted rods proved best for reinforcing concrete fence posts, and when these are placed about three-fourths inch from the surface they give the greatest strength.

Silo walls.

For treating silo walls a plastic bitumen material, protected by plaster, gave the best results at the Minnesota station.

Retention of irrigation water.

Studies in soil moisture at the Oregon station show that the coarsest irrigated soil retains about one-half inch of usable water to the acre-foot, heavy silty clay loam about 2 inches, fine sand 1 inch, and sandy loam 1½ inches. The duty of water for alfalfa was not less than 5¼ to 6 inches per ton.

SUGAR MAKING.

At the Louisiana station investigations on the clarification of cane juices indicate that there is little advantage in removing the sulphur precipitate from raw cane juice before liming. The use of suitable dyestuffs as indicators in the control of the sulphitation process, to determine the end point of sulphitation and liming, was found to be satisfactory and much less time-consuming than titration. No means have been found to prevent the formation of the precipitate when clarified cane juice is evaporated to sirup, which appears to result from flocculation of colloidal matter, natural to the juice, regardless of treatment. It is found that carbons decolorize better if the juice is acid, but the time of acidifying and decolorizing should be made as short as possible to prevent inversion.

Deterioration of cane sugar was found not to occur in the outer exposed parts of the bags, bacteria being more numerous in the center. By the use of superheated steam in the centrifugals it was possible to reduce the number of organisms over 90 per cent, thereby eliminating one of the most important factors in sugar and molasses deterioration. As most of the bacteria apparently go out of the centrifugal into the molasses, in order to sterilize both the sugar and the molasses the steam must be turned on when the centrifugal is started. Most of the infection is due to wash water and air currents.

RURAL ECONOMICS.

Partly through the efforts of the California station a State land settlement board has been created by the legislature, the settlements

under which have demonstrated the practicability of a credit system based on the character of the borrower, long-time amortized payments on land, community action in the improvement of live stock, cooperation in the purchase of equipment and the selling of products, and the effecting of better living conditions in rural communities.

An extensive survey by the Indiana station showed that the successful farms studied owe their success to a large farm business, efficient use of man and horse labor, more live stock, better live stock, and large crop yields.

The Mississippi station found the largest labor incomes to be on farms having 16 per cent in cotton, 12 per cent in corn, and 26.5 per cent in oats. Corn and hogs were not profitable. The Utah station reports that farmers with only a grade schooling made an average labor income of $446, those who had attended high school made $805, and those of more than a high-school education made $2,770.

From data secured by the Missouri station it is shown that approximately 80 per cent more man labor and 40 per cent more horse labor is required to grow an acre of corn on fields under 10 acres in size than on fields of more than 30 acres.

The Missouri station finds that the 1920 wheat crop cost the Missouri farmer $2.26 a bushel to produce, the oat crop $0.82 a bushel, and the corn crop $1.01 a bushel. Figures obtained by the Washington station show that the average cost of producing winter wheat in 1919 was $1.63 per bushel on owned land and $1.54 on tenant farms, ranging from $0.70 to $4 per bushel. Spring wheat ranged from $0.80 to $4. The data secured indicated a material reduction in the cost of producing wheat where peas were grown on the summer fallow.

Studies at the Indiana station on the cost of producing beef show that feed constitutes 70 to 85 per cent of all expenses other than the initial cost of the animals. Man and horse labor constitute 5 to 7 per cent, depreciation and upkeep of buildings and fences 5 to 6 per cent, interest on investment 3 to 4 per cent, marketing costs 2 per cent, and death-risk insurance and taxes 2 to 4 per cent. Credit for pork and manure approximate all the costs other than feed when corn is fed in the ration.

INSULAR EXPERIMENT STATIONS.

The work and expenditures of the experiment stations located in Alaska, Hawaii, Porto Rico, Guam, and the Virgin Islands are published as separate reports. The Office of Experiment Stations exercises general supervision over these stations, which derive their support from direct Federal appropriation to the Department of Agriculture. They are under the immediate charge of W. H. Evans.

VISITATION OF THE STATIONS.

Each of the continental stations receiving Federal funds was visited by a representative of the office during the year for an examination of the work and expenditures, presenting also an opportunity to confer with the station officers in regard to organization and administration. These examinations were made by the chief (E. W. Allen), W. H. Evans, W. H. Beal, E. R. Flint, and J. I. Schulte.

These visits, with the extensive correspondence during the year, the careful review and approval of the projects carried on under the Adams fund, and the examination of the financial reports at the close of the year, before they are formally approved, serve to keep the office in close touch with the work and administration of these institutions.

STATISTICS OF THE STATIONS.

For the fiscal year ended June 30, 1921, the total income reported by the experiment stations from all sources was $7,660,570.77. This amount includes $1,440,000 derived from Federal sources under the Hatch and Adams Acts and $210,000 appropriated by the Federal Government for the experiment stations in Alaska and the insular possessions.

The support of the stations from within the States included $3,786,997.94 derived from State appropriations or apportionments, $359,964.92 from fees, $1,167,856.62 from the sale of farm and other products, $371,421.86 from miscellaneous sources, and $534,329.43 carried over as balances from the previous year. As the State fiscal year does not in all cases coincide with that of the Federal Government, and as unexpended balances on State appropriations are usually permitted to be carried forward to the succeeding year, the above amounts were not fully expended, but portions were carried over to the fiscal year 1922. The amount of this carry over there are no data for estimating at the present time.

The resources as stated above, which come from within the State, can not be accepted at absolutely face value, but need interpretation. In a considerable number of the States the experiment station has no budget of its own or specific appropriation for its use. Fully a third of the stations receive their State aid through an allotment made by the college authorities from the general appropriation of the college. Sometimes this is a definite amount, set apart for the use of the station, and in others it is allotted in connection with the general support of college departments without specifying the proportion or amount to be devoted to the station. Where no account is kept of the expenditures on account of the station work, the returns are largely an estimate, based on the percentage of the entire fund of the college or on the judgment of administrative officers. Some institutions make a very careful estimate based on an analysis of individual department expenditures, while others can only attempt an approximation, which there are evidences may not be very accurate for a given year. This makes it very difficult to compile statistics of State revenues which are accurate, although efforts are made from year to year to check up the revenues as reported and to secure as close an approximation as possible. Furthermore, these State funds often cover the appropriations for inspections and regulatory work of a wide variety.

The proceeds from sales constitute another item which is subject to interpretation. In individual cases these may include the sales from the entire college farm, or from parts in which the experiment station is not concerned. The item is swelled by commercial enterprises outside the range of the station proper and in the proceeds

from which it only profits quite incidentally. It can not be assumed, therefore, that the aggregate amount of the sales fund is station revenue or is available for carrying on the station investigations. It fluctuates from year to year, and in institutions like the colleges and stations it is likely to represent a net expense or at most a turnover. If it were possible to estimate accurately the revenues at the disposal of the stations for the activities lying within their specific field, it is believed that the total amount would shrink quite materially.

During the year the stations added to their buildings and equipment to the extent of nearly a million dollars. These additions are classified as follows:

Buildings	$459,644.38
Library	29,023.53
Apparatus	67,598.63
Farm implements	107,490.62
Live stock	147,229.36
Miscellaneous	181,321.51
Total	992,308.03

In the work of administration and inquiry the experiment stations employed 1,965 persons. Of these, 1,023 were also members of the teaching staffs of the colleges and 434 assisted in the various lines of extension work.

During the year the stations issued 830 publications, including annual reports, bulletins, circulars, press bulletins, etc., aggregating 20,148 pages. These were distributed to nearly 900,000 addresses on regular mailing lists, in addition to the numbers sent in response to special requests, which show constant increase.

The statistics of the stations by States are given in detail in the following tables:

Station.	Location.	Director.	Date of original organization.	Date of organization under Hatch Act.	Number on staff.	Number of teachers on staff.	Number of persons on staff who assist in extension work.	Publications during fiscal year 1920–21.		Number of names on mailing list.
								Number.	Pages.	
Alabama (College)	Auburn	J. F. Duggar	Feb. —, 1883	Feb. 24, 1888	22	9	6	4	108	20,000
Alabama (Canebrake)	Uniontown	J. M. Burgess	Jan. 1, 1886	Apr. 1, 1888						
Alabama	Tuskegee Institute	G. W. Carver	Feb. 15, 1897		5	4				
Alaska	Sitka	C. C. Georgeson			9			2	194	4,200
Arizona	Tucson	D. W. Working		—— —, 1889	23	16	5	15	302	8,500
Arkansas	Fayetteville	Bradford Knapp		—— —, 1887	21	21	6	3	83	10,000
California	Berkeley	C. M. Haring	—— —, 1875	Mar. —, 1888	120	78	60	36	1,095	39,300
Colorado	Fort Collins	C. P. Gillette		Feb. 29, 1888	40	9	9	13	491	2,800
Connecticut (State)	New Haven	E. H. Jenkins	Oct. 1, 1875	May 18, 1887	19	1		6	406	9,800
Connecticut (Storrs)	Storrs	do		do	12	6	8	2	48	7,000
Delaware	Newark	C. A. McCue		Feb. 21, 1888	14	9	3	3	126	9,000
Florida	Gainesville	Wilmon Newell		—— —, 1888	12		7	8	58	18,000
Georgia	Experiment	H. P. Stuckey	Feb. 18, 1888	July 1, 1889	6			41	50	6,000
Guam	Guam	C. W. Edwards			4			2	62	2,900
Hawaii	Honolulu	J. M. Westgate			6		6	1	73	2,427
Idaho	Moscow	E. J. Iddings		Feb. 26, 1892	39	18	18	20	172	11,000
Illinois	Urbana	Eugene Davenport		Mar. 21, 1888	78	67	20	12	228	42,000
Indiana	Lafayette	G. I. Christie	—— —, 1885	Jan. —, 1888	61	18	6	16	740	38,124
Iowa	Ames	C. F. Curtiss		Feb. 17, 1888	71	22	10	20	733	33,000
Kansas	Manhattan	F. D. Farrell		Feb. 8, 1888	75	30		12	603	12,500
Kentucky	Lexington	T. P. Cooper	Sept. —, 1885	Apr. —, 1888	55	20	10	7	308	20,000
Louisiana (Sugar)	New Orleans		Sept. —, 1885							
Louisiana (State)	Baton Rouge	W. H. Dalrymple	Apr. —, 1886		23	3	9	9	340	9,000
Louisiana (North)	Calhoun		May —, 1887							
Maine	Orono	W. J. Morse	Mar. —, 1885	Oct. 1, 1887	17			37	629	20,950
Maryland	College Park	H. J. Patterson	—— —, 1888	Apr. —, 1888	30	19		8	194	20,000
Massachusetts	Amherst [1]	S. B. Haskell	—— —, 1882	Mar. 2, 1888	47	7	1	23	452	21,663
Michigan	East Lansing	R. S. Shaw		Feb. 26, 1888	66	51	20	19	896	45.000
Minnesota	University farm, St. Paul	R. W. Thatcher	Mar. 7, 1885	—— —, 1888	85	68	50	8	683	11,000
Mississippi	Agricultural College	J. R. Ricks		Jan. 27, 1888	30	20		19	285	13,000
Missouri (College)	Columbia	F. B. Mumford		Jan. —, 1888	45	45		87	1,347	6,368
Missouri (Fruit)	Mountain Grove	F. W. Faurot	Feb. 1, 1900		4					
Montana	Bozeman	F. B. Linfield		July 1, 1893	28	15		15	314	11,00
Nebraska	Lincoln	E. A. Burnett	Dec. 16, 1884	June 13, 1887	38	32	2	9	224	8,500
Nevada	Reno	S. B. Doten		Dec. —, 1887	8	3	1	3	70	6,000
New Hampshire	Durham	J. C. Kendall	—— —, 1886	Aug. 4, 1887	20	14	15	7	151	22,000
New Jersey (State)	New Brunswick	J. G. Lipman	Mar. 10, 1880		42	20	39	53	1,750	17,000
New Jersey (College)	do	do		Apr. 26, 1888	17					

[1] In 1882 the State organized a station here and maintained it until June 18, 1895, when it was combined with the Hatch Station at the same place.

General statistics, 1921—Continued.

Station.	Location.	Director.	Date of original organization.	Date of organization under Hatch Act.	Number on staff.	Number of teachers on staff.	Number of persons on staff who assist in extension work.	Publications during fiscal year 1920–21.		Number of names on mailing list.
								Number.	Pages.	
New Mexico	Agricultural College	Fabian Garcia		Dec. 14, 1889	17	13	7	34	318	10,000
New York (State)	Geneva	W. H. Jordan	Mar. —, 1882		41			17	447	47,756
New York (Cornell)	Ithaca	A. R. Mann	—— —, 1879	Apr. —, 1888	60	60	11	4	337	2,869
North Carolina (College)	West Raleigh	B. W. Kilgore	Mar. 12, 1877	Mar. 7, 1887	45	4	3	3	112	4,950
North Dakota	Agricultural College	P. F. Trowbridge		Mar. —, 1890	31	10	3	12	338	8,841
Ohio	Wooster	C. G. Williams	Apr. 25, 1882	Apr. 2, 1888	54			65	696	71,597
Oklahoma	Stillwater	H. G. Knight		Dec. 25, 1890	22	19		6	128	5,340
Oregon	Corvallis	J. T. Jardine		July —, 1888	55	30		14	732	1,064
Pennsylvania	State College	R. L. Watts		June 30, 1887	69	68	69	6	164	40,800
Pennsylvania (Nutrition)	do	H. P. Armsby	——, 1907		8					500
Porto Rico	Mayaguez	D. W. May			9		1	6	157	3,400
Rhode Island	Kingston	B. L. Hartwell		July 30, 1888	12	3		6	126	1,850
South Carolina	Clemson College	H. W. Barre		Jan. —, 1888	23	7	6	5	240	5,000
South Dakota	Brookings	J. W. Wilson		Mar. 13, 1887	15	16		5	137	2,000
Tennessee	Knoxville	H. A. Morgan	June 8, 1882	Aug. 4, 1887	18	1		8	138	12,100
Texas	College Station	B. Youngblood		Apr. 3, 1889	46	1		26	1,136	55,000
Utah	Logan	F. S. Harris		——, 1890	37	36	14	9	392	10,000
Vermont	Burlington	J. L. Hills	Nov. 24, 1886	Feb. 28, 1888	12	9	2	2	72	2,500
Virginia	Blacksburg	A. W. Drinkard, jr	——, 1888	——, 1891	25	11		8	234	11,000
Virginia (Truck)	Norfolk	T. C. Johnson			7			3	69	6,500
Virgin Islands	St. Croix	L. Smith			2		2	3	65	500
Washington	Pullman	E. C. Johnson		——, 1891	40	12		9	298	14,605
West Virginia	Morgantown	J. L. Coulter		June 11, 1888	32	25	4	31	346	20,000
Wisconsin	Madison	H. L. Russell	——, 1883	——, 1887	87	63	40	23	752	46,875
Wyoming	Laramie	A. D. Faville		Mar. 1, 1891	16	10	1	5	166	6,000
Total					1,965	1,023	434	830	20,148	899,079

Station.	Federal.		State.	Balances from previous year.[1]	Fees.	Sales.	Miscellaneous.	Total.	Additions to equipment.						
	Hatch fund.	Adams fund.							Buildings.	Library.	Apparatus.	Farm implements.	Live stock.	Miscellaneous.	Total.
Alabama (College)	$15,000.00	$15,000.00	$34,500.00	$7,118.69	.....	$2,718.72	.....	$74,337.41	.....	.....	$950.00	$205.00	.....	$350.00	$1,505.00
Alaska[2]	.....	.....	.....	.....	.....	.....	$75,000.00	75,000.00	.....	.....	.....	.....	.....	.....	.....
Arizona	15,000.00	15,000.00	49,281.97	13,451.90	.....	11,776.28	.....	104,510.15	$19,699.04	$7.87	444.58	1,009.04	$1,847.75	295.20	23,303.48
Arkansas	15,000.00	15,000.00	43,074.67	.....	.....	10,284.88	.....	83,359.55	781.81	1,146.04	2,044.58	1,130.24	2,094.84	45,503.34	52,700.85
California[3]	15,000.00	15,000.00	147,378.71	374.04	$3,583.39	62,069.10	40,921.87	284,327.11	30,241.90	2,811.86	5,445.30	15,311.80	5,205.54	2,343.08	61,359.48
Colorado	15,000.00	15,000.00	75,329.33	49,683.66	.....	.....	.....	155,012.99	6,129.87	411.78	7,036.96	1,039 91	6,793.52	19,938.07	41,350.11
Connecticut (State)	7,500.00	7,500.00	38,200.00	13.45	17,000.00	.....	12,792.87	83,006.32	30.00	495.03	154.15	552.66	57.50	437.79	1,727.13
Connecticut (Storrs)	7,500.00	7,500.00	27,821.74	.....	.....	.....	18,881.60	61,703.34	.....	31.74	.....	360.00	1,084.00	.....	1,475.74
Delaware	15,000.00	15,000.00	10,000.00	.....	.....	14,799.35	.....	54,799.35	.....	281.73	1,260.07	2,484.14	3,263.48	.....	7,289.42
Florida	15,000.00	15,000.00	5,000.00	3,979.94	.....	5,891.83	3,782.15	48,653.92	310.11	599.10	534.58	171.02	.....	236.17	1,850.98
Georgia	15,000.00	15,000.00	51.08	5,161.32	.....	6,207.97	.....	41,420.37	1,261.49	283.53	81.14	312.10	1,269.83	35,136.60	38,344.69
Guam[2]	.....	.....	.....	.....	.....	.....	15,000.00	15,000.00	.....	.....	.....	.....	.....	.....	.....
Hawaii[2]	.....	.....	.....	.....	.....	.....	50,000.00	50,000.00	.....	453.64	238.00	1,051.42	500.00	248.67	2,491.73
Idaho	15,000.00	15,000.00	21,257.38	768.48	.....	2,389.49	.....	54,415.35	1,200.00	90.00	1,550.00	1,000.00	3,000.00	1,400.00	8,240.00
Illinois	15,000.00	15,000.00	140,000.00	15,633.54	.....	98,617.48	.....	284,251.02	51.81	.....	3,117.78	3,210.34	3,044.04	.....	9,423.97
Indiana	15,000.00	15,000.00	150,232.87	70,344.32	98,638.19	110,384.74	.....	459,600.12	32,389.08	1,010.16	800.06	4,766.34	19,113.91	3,785.02	61,864.57
Iowa	15,000.00	15,000.00	140,500.00	66,980.05	.....	37,051.61	29.25	274,560.91	74,877.54	.....	1,014.04	4,432.16	5,551.44	781.88	86,657.16
Kansas	15,000.00	15,000.00	82,000.00	22,000.22	.....	60,932.68	.....	194,932.90	1,000.00	25.00	597.03	922.20	3,096.50	.....	5,640.73
Kentucky	15,000.00	15,000.00	50,000.00	75,295.77	96,589.32	53,484.43	.....	305,369.52	4,131.61	415.36	970.86	400.00	1,565.00	1,530.38	9,013.21
Louisiana	15,000.00	15,000.00	49,993.96	434.76	.....	9,035.04	1,766.87	91,236.63	832.87	417.97	2,031.88	3,911.24	1,143.20	5,292.93	13,630.09
Maine	15,000.00	15,000.00	15,000.00	.....	12,486.65	25,091.51	17,862.72	100,440.91	13,019.29	851.59	287.33	2,493.27	1,621.07	491.25	18,763.80
Maryland	15,000.00	15,000.00	51,028.02	.....	.....	18,432.99	.....	102,461.01	.....	401.89	712.01	4,984.91	369.42	795.63	7,263.86
Massachusetts	14,000.00	15,000.00	83,500.00	.....	15,035.88	10,128.13	343.56	138,767.57	914.80	691.98	375.96	978.46	1,143.00	167.16	4,271.36
Michigan	15,000.00	15,000.00	197,013.29	.....	25,420.00	7,637.23	5,968.87	266,039.39	18,959.43	641.54	1,561.22	4,242.94	3,369.04	.....	28,774.17
Minnesota	15,000.00	15,000.00	219,000.00	.....	.....	80,579.38	3,092.30	332,671.68	17,568.77	1,678.09	2,524.87	5,289.26	15,987.88	3,222.22	46,271.09
Mississippi	15,000.00	15,000.00	94,829.53	16,359.56	90.00	7,485.19	423.22	149,187.50	37,350.00	349.08	493.68	5,014.25	2,624.50	3,342.30	49,173.81
Missouri (College)	15,000.00	15,000.00	35,201.33	12,047.10	30,165.82	14,420.04	.....	121,834.29	2,632.12	389.63	1,810.40	442.13	4,951.17	868.40	11,093.85
Montana	15,000.00	15,000.00	79,395.51	.....	.....	18,863.89	.....	128,259.40	.....	230.00	1,030.00	3,500.00	150.00	.....	4,910.00
Nebraska	15,000.00	15,000.00	51,723.55	30,320.09	.....	73,499.98	.....	185,513.62	.....	2,250.00	862.95	882.46	855.18	.....	4,850.59
Nevada	15,000.00	15,000.00	140.87	244.09	.....	941.63	.....	31,326.59	964.17	117.36	37.58	861.15	1,694.60	68.80	3,743.66
New Hampshire	15,000.00	15,000.00	.....	1,315.11	.....	2,654.78	15,970.42	49,940.31	.....	350.00	2,109.92	35.00	150.00	367.20	3,012.12
New Jersey(State)	.....	.....	119,162.64	.....	50,032.42	36,608.01	.....	205,803.07	.....	.....	.....	.....	.....	.....	.....

[1] Not including balances from Federal funds.
[2] Federal appropriations.
[3] The resources from other than Federal funds are estimated.

Revenue and additions to equipment, 1921—Continued.

Station.	Federal.		State.	Balances from previous year.[1]	Fees.	Sales.	Miscellaneous.	Total.	Additions to equipment.						
	Hatch fund.	Adams fund.							Buildings.	Library.	Apparatus.	Farm implements.	Live stock.	Miscellaneous.	Total.
New Jersey (College)[2]	$15,000.00	$15,000.00						$30,000.00	$75,000.00	$700.00	$500.00	$500.00	$2,000.00		$78,700.00
New Mexico	15,000.00	15,000.00	$7,500.00	$14,007.65		$7,133.92		58,641.57	415.51	8.33	306.27	662.63	95.00	$149.02	1,636.76
New York (State)[2]	1,500.00	1,500.00	185,829.22	5,005.45				193,834.67		930.00	1,200.00				2,130.00
New York (Cornell)	13,500.00	13,500.00	192,629.81		$10,863.25	27,362.40	$10,351.57	268,207.03	6,919.09	897.52	2,937.87	3,864.67	206.29	3,927.19	18,752.63
North Carolina (College)	15,000.00	15,000.00	103,550.00			3,532.46	3,750.00	140,832.46	3,500.00	212.62	70.00	297.11			4,079.73
North Dakota	15,000.00	15,000.00	103,108.90			53,771.29	6,825.00	193,705.19	2,500.00	82.85	1,265.73	4,730.65	9,579.55	738.87	18,897.65
Ohio	15,000.00	15,000.00	265,365.00	58,430.39		43,571.88		397,367.27	28,265.53	1,061.86	1,538.43	942.10	1,030.25		32,778.17
Oklahoma	15,000.00	15,000.00	10,000.00	1,655.88		7,595.85		49,251.73	400.50	964.71	219.19	607.85	2,926.43	271.92	5,390.60
Oregon	15,000.00	15,000.00	92,750.00	8,866.30		42,505.42	4,000.00	178,121.72		20.00	1,229.33	2,159.97	7,385.54	2,750.36	13,545.20
Pennsylvania	15,000.00	15,000.00		3,669.43				33,669.43		202.24	719.45	2,900.14	2,400.00		6,221.83
Porto Rico[3]							50,000.00	50,000.00	2,224.11	108.24	228.35	354.97	160.00	15.56	3,091.23
Rhode Island	15,000.00	15,000.00	1,693.29	684.37		7,863.05		40,240.71		259.81	357.00	401.45	92.00	2.50	1,112.76
South Carolina	15,000.00	15,000.00	50,000.00	2,219.43		13,840.63	5,467.55	101,527.61	11,000.00	1,321.35	1,173.79	1,443.73	4,661.00		19,599.87
South Dakota	15,000.00	15,000.00	14,460.00	7,009.45		1,399.26	8,198.39	61,067.10			900.00	850.00		325.00	2,075.00
Tennessee	15,000.00	15,000.00	31,904.27			647.23		62,551.50		600.34	231.52	2,951.02	3,065.62	423.25	7,271.75
Texas	15,000.00	15,000.00	220,519.17	4,517.30		56,772.08		311,808.55	21,249.51	525.04	5,045.38	5,368.88	5,166.11	9,885.16	47,240.08
Utah	15,000.00	15,000.00	53,468.29	8,272.21		28,837.23		120,577.73	2,000.00	900.00	3,000.00	500.00	1,000.00	7,125.00	14,525.00
Vermont	15,000.00	15,000.00						30,000.00	488.79	152.30	966.40	39.80	425.00		2,072.29
Virginia	15,000.00	15,000.00	38,350.00	6,276.78		12,341.87	993.65	87,962.30	1,102.43	398.72	386.03	1,211.94		46.13	3,145.25
Virgin Islands[3]							20,000.00	20,000.00	1,276.97	36.79	128.00	286.00		13.64	1,741.40
Washington	15,000.00	15,000.00	87,760.47	18,730.51		42,864.90		179,355.88	18,020.09	647.59	1,011.75	2,424.33	6,146.38	1,442.63	29,692.77
West Virginia	15,000.00	15,000.00	104,787.07	2,749.97		30,119.46		167,656.50	20,600.00	338.42	591.76	1,309.92	3,802.56	25,147.58	51,790.24
Wisconsin	15,000.00	15,000.00	210,000.00					240,000.00		929.10	2,423.77	2,382.16	3,984.26	1,662.03	11,381.32
Wyoming	15,000.00	15,000.00		708.22		5,711.30		36,419.52	336.14	1,353.73	1,091.68	307.86	1,556.96	793.48	5,439.85
Total	720,000.00	720,000.00	3,786,997.94	534,329.43	359,964.92	1,167,856.62	371,421.86	7,660,570.77	459,644.38	29,023.53	67,598.63	107,490.62	147,229.36	181,321.51	992,308.03

[1] Not including balances from Federal funds.
[2] Including balances from previous year: $0.51 Hatch and $34.78 Adams (New York State Station); $166.72 Adams (New Jersey).
[3] Federal appropriations.

Expenditures from United States appropriations received under the

Station.	Amount of appropriation.	Classified expenditures.						
		Salaries.	Labor.	Publications.	Postage and stationery.	Freight and express.	Heat, light, and water.	Chemical supplies.
Alabama	$15,000.00	$7,852.51	$2,652.36	$486.02	$894.17	$170.03	$117.63	$99.95
Arizona	15,000.00	13,248.73	65.12	.....	76.10	18.67	.....	93.64
Arkansas	15,000.00	8,070.00	1,394.18	135.13	206.96	255.20	103.19	178.70
California	15,000.00	15,000.00	.....	.....	.....	.....	.....	.....
Colorado	15,000.00	10,996.83	1,272.68	695.35	302.40	5.40	.....	94.70
Connecticut (State)	7,500.00	7,500.00	.....	.....	.....	.....	.....	.....
Connecticut (Storrs)	7,500.00	7,500.00	.....	.....	.....	.....	.....	.....
Delaware	15,000.00	8,103.31	2,544.57	1,486.13	718.71	27.06	331.44	68.81
Florida	15,000.00	8,697.50	2,147.53	812.33	758.30	347.79	343.25	12.45
Georgia	15,000.00	8,024.93	3,660.61	629.82	312.92	145.31	571.61	33.22
Idaho	15,000.00	10,757.19	1,884.29	.....	17.86	67.73	38.75	527.41
Illinois	15,000.00	14,842.37	157.63	.....	.....	.....	.....	.....
Indiana	15,000.00	13,408.32	1,273.98	.....	5.46	.....	.....	84.69
Iowa	15,000.00	8,396.35	1,257.94	757.67	1,137.29	46.44	336.55	11.75
Kansas	15,000.00	8,898.34	5,262.07	10.30	239.54	.....	12.00	7.55
Kentucky	15,000.00	14,975.00	.....	.....	.....	.....	.....	.....
Louisiana	15,000.00	7,970.75	3,232.10	833.60	72.21	10.10	195.53	.....
Maine	15,000.00	8,387.12	1,368.44	159.93	390.89	71.89	615.16	8.00
Maryland	15,000.00	12,182.49	826.35	412.00	3.49	.....	178.27	55.23
Massachusetts	15,000.00	14,902.50	97.50	.....	.....	.....	.....	.....
Michigan	15,000.00	15,000.00	.....	.....	.....	.....	.....	.....
Minnesota	15,000.00	15,000.00	.....	.....	.....	.....	.....	.....
Mississippi	15,000.00	9,587.55	3,874.23	.....	39.74	32.28	382.16	.....
Missouri	15,000.00	9,315.59	2,837.38	198.81	128.23	195.57	65.84	100.20
Montana	15,000.00	12,507.87	661.86	.....	145.47	66.49	75.37	52.33
Nebraska	15,000.00	7,299.40	2,942.78	1,495.85	112.20	23.96	.....	192.04
Nevada	15,000.00	8,417.15	2,201.00	650.39	263.91	119.62	156.20	1.25
New Hampshire	15,000.00	9,451.85	983.85	1,263.16	533.30	349.75	600.00	65.16
New Jersey	15,000.00	9,162.93	1,303.11	504.98	265.27	40.20	91.22	907.81
New Mexico	15,000.00	4,762.75	3,544.08	2,738.09	85.16	154.18	134.52	151.88
New York (State)[1]	1,500.00	150.00	1,020.00	.....	69.85	35.62	.....	.....
New York (Cornell)	13,500.00	9,285.00	2,510.89	.....	14.27	.....	11.45	751.00
North Carolina	15,000.00	11,863.84	3,136.16	.....	.....	.....	.....	.....
North Dakota	15,000.00	14,930.45	.....	.....	.....	.....	.....	69.55
Ohio	15,000.00	6,964.76	4,481.44	.....	116.19	1,337.02	.....	67.01
Oklahoma	15,000.00	8,256.62	1,992.80	733.75	269.37	.....	67.41	434.57
Oregon	15,000.00	12,480.66	535.73	1,274.61	40.18	63.18	.....	1.40
Pennsylvania	15,000.00	11,316.29	510.66	1,477.11	106.86	89.99	31.44	242.33
Rhode Island	15,000.00	5,774.28	4,094.97	1,619.52	108.37	167.18	54.61	71.58
South Carolina	15,000.00	7,290.72	3,423.30	365.62	749.78	260.74	22.50	24.58
South Dakota	15,000.00	9,939.91	2,510.20	1,146.90	36.16	.44	.....	605.46
Tennessee	15,000.00	10,265.72	871.86	1,187.50	411.95	44.69	746.70	1.91
Texas	15,000.00	10,883.22	2,323.07	.....	608.09	20.08	.....	202.73
Utah	15,000.00	10,389.26	2,436.49	.....	120.83	100.26	275.95	355.98
Vermont	15,000.00	6,809.16	1,593.12	3,126.74	167.66	27.09	1,238.50	161.03
Virginia	15,000.00	9,618.26	2,849.12	316.09	222.10	87.52	528.97	76.72
Washington	15,000.00	8,667.82	3,277.87	1,600.79	71.06	.....	.....	5.40
West Virginia	15,000.00	12,122.60	702.22	564.40	8.00	24.63	.....	152.25
Wisconsin	15,000.00	8,600.00	2,573.75	458.36	19.34	1.97	.....	841.34
Wyoming	15,000.00	11,381.25	80.25	363.75	.....	1.77	40.39	161.27
Total	720,000.00	497,209.15	88,369.54	27,504.70	9,849.64	4,409.85	7,366.61	6,972.88

[1] Including a balance of $0.51.

act of March 2, 1887 (Hatch Act), for the year ended June 30, 1921.

Classified expenditures.											
Seeds, plants, and sundry supplies.	Fertilizers.	Feeding stuffs.	Library.	Tools, implements, and machinery.	Furniture and fixtures.	Scientific apparatus.	Live stock.	Traveling expenses.	Contingent expenses.	Buildings and repairs.	Balances.
$388.58	.....	$231.30	$574.73	$241.65	$718.04	$16.84	.....	$280.57	.....	$275.62	.....
56.90	.....	.....	5.00	.....	53.40	366.42	$800.00	130.71	.....	85.31	.....
1,180.05	$200.12	993.90	4.50	1,082.80	118.46	172.18	612.04	286.34	.....	6.25	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
178.45	.....	212.98	44.83	46.50	63.40	232.55	189.60	293.83	.....	370.50	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
433.58	147.00	.....	232.17	65.65	345.25	60.02	.....	431.35	$4.95	.....	.....
76.52	8.12	823.20	531.43	196.37	100.92	.....	.....	115.34	10.15	18.80	.....
601.49	296.80	50.40	211.71	207.03	20.55	.94	39.00	180.43	.....	13.23	.....
245.32	.....	571.75	10.60	119.00	84.00	58.74	.....	603.31	5.00	9.05	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3.93	.....	199.45	.....	.....	.....	.....	.....	24.17	.....	.....	.....
600.47	26.02	1,737.47	.....	124.55	13.77	265.00	.....	283.40	5.33	.....	.....
269.38	.....	.....	.....	194.16	.....	.....	.....	51.86	.....	54.80	.....
.....	.....	25.00	.....	.....	.....	.....	.....	.....	.....	.....	.....
270.67	551.05	737.88	17.00	178.08	20.00	.....	.....	185.00	.....	726.03	.....
246.80	333.16	2,460.05	190.26	339.34	42.25	29.01	.....	315.93	25.62	16.15	.....
489.56	.....	.....	5.50	32.11	599.25	158.35	.....	.....	.....	57.40	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
274.71	100.18	709.15	.....	.....	.....	.....	.....	.....	.....	.....	.....
353.53	.....	1,067.57	.....	14.84	8.01	26.33	253.95	116.04	.....	318.11	.....
166.50	6.30	148.25	54.38	25.95	473.30	88.11	.....	527.82	.....	.....	.....
343.82	.....	1,315.44	21.40	511.65	357.25	180.71	11.00	192.50	.....	.....	.....
394.68	.....	425.20	53.57	787.87	66.30	35.08	105.75	774.40	.....	547.63	.....
250.22	44.45	.....	361.45	17.29	325.00	59.39	.....	687.57	.....	7.56	.....
610.64	8.30	.....	82.69	60.62	104.15	34.58	.....	1,683.32	10.20	129.98	.....
242.53	81.61	2,642.54	.....	37.33	48.61	.....	25.00	324.22	.....	27.50	.....
98.21	.....	.....	7.00	.....	.....	75.94	.....	35.54	.....	.....	$7.84
432.70	60.80	.....	.....	139.18	20.81	255.70	.....	18.20	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
240.74	449.49	197.49	56.35	163.60	.....	353.18	.....	.....	.....	572.73	.....
360.42	.....	1,506.67	462.50	380.80	102.95	4.13	67.20	298.81	.....	62.00	.....
27.97	.....	.....	.....	101.90	.....	289.89	.....	184.48	.....	.....	.....
366.90	258.12	.....	28.09	23.99	9.24	46.69	.....	344.03	.....	148.26	.....
279.68	1,434.66	519.05	345.55	97.73	2.10	54.45	.....	113.33	.....	262.94	.....
353.71	.....	1,295.81	479.75	264.79	201.79	.....	.....	175.32	.....	91.59	.....
272.58	.....	28.65	6.80	128.00	8.80	142.00	90.00	.....	.....	84.10	.....
75.16	26.75	.....	515.81	53.28	108.25	5.25	.....	217.69	.....	467.48	.....
130.14	6.00	3.50	25.10	82.12	263.81	.....	152.29	.....	.....	299.85	.....
552.13	.....	.....	170.65	129.14	28.27	18.10	.....	388.76	.....	34.18	.....
636.30	83.81	224.10	136.84	38.93	55.99	477.46	.....	140.38	.....	82.89	.....
332.64	153.55	36.00	379.88	230.43	3.16	10.59	2.00	85.24	.....	67.73	.....
467.71	9.03	.....	18.00	96.15	389.15	66.50	.....	262.57	.....	67.95	.....
342.19	258.14	.....	.....	6.30	125.35	5.18	.....	688.74	.....	.....	.....
588.04	119.28	570.07	.....	305.57	23.59	856.68	.....	41.01	1.00	.....	.....
117.20	45.00	2,583.50	.....	38.84	.....	101.86	.....	84.92	.....	.....	.....
13,352.75	4,707.74	21,316.37	5,033.54	6,563.54	4,905.17	4,547.85	2,347.83	10,567.13	62.25	4,905.62	7.84

Expenditures from United States appropriations received under the

Station.	Amount of appropriation.	Classified expenditures.						
		Salaries.	Labor.	Postage and stationery.	Freight and express.	Heat, light, and water.	Chemical supplies.	Seeds, plants, and sundry supplies.
Alabama	$15,000.00	$10,112.54	$678.78	$26.00	$143.21	.....	$773.81	$242.10
Arizona	15,000.00	14,328.84	.....	27.61	4.26	.....	83.44	49.42
Arkansas	15,000.00	9,309.98	1,308.84	64.15	128.79	$112.43	405.20	308.38
California	15,000.00	11,424.92	1,988.94	3.90	37.11	19.41	199.19	503.52
Colorado	15,000.00	12,812.75	421.30	31.72	1.75	.....	533.85	86.48
Connecticut (State)	7,500.00	5,495.89	133.25	123.22	64.80	612.00	301.32	308.71
Connecticut (Storrs)	7,500.00	7,500.00	.....	.....	.....	.....	.....	.....
Delaware	15,000.00	11,188.25	850.76	7.45	93.45	.....	1,154.41	252.17
Florida	15,000.00	9,736.67	961.49	58.35	255.26	77.50	878.28	398.68
Georgia	15,000.00	9,858.33	378.45	67.39	161.19	584.38	793.09	192.47
Idaho	15,000.00	10,756.25	1,575.45	16.10	325.93	72.60	614.86	396.84
Illinois	15,000.00	13,208.44	1,035.00	.14	2.78	.....	64.52	55.00
Indiana	15,000.00	11,380.00	692.38	112.00	3.81	.....	703.64	32.93
Iowa	15,000.00	8,648.89	3,151.17	165.20	.....	276.18	1,201.78	427.28
Kansas	15,000.00	9,108.33	3,236.94	20.00	5.80	2.90	447.99	350.01
Kentucky	15,000.00	14,612.34	.....	.....	.....	.....	21.54	1.96
Louisiana	15,000.00	9,574.35	411.60	20.92	44.31	577.38	975.21	287.73
Maine	15,000.00	11,532.55	825.94	73.23	83.85	115.93	119.70	154.91
Maryland	15,000.00	12,712.36	286.50	36.32	2.00	659.82	459.84	196.99
Massachusetts	15,000.00	14,171.24	512.82	.....	.....	.....	.....	63.88
Michigan	15,000.00	15,000.00	.....	.....	.....	.....	.....	.....
Minnesota	15,000.00	15,000.00	.....	.....	.....	.....	.....	.....
Mississippi	15,000.00	10,344.82	3,198.82	.....	288.48	124.51	328.28	208.75
Missouri	15,000.00	6,431.71	1,663.14	11.61	197.25	120.84	1,213.39	326.20
Montana	15,000.00	12,604.08	175.08	92.65	10.63	16.80	397.75	146.02
Nebraska	15,000.00	11,666.10	618.87	2.89	2.92	.....	88.40	374.55
Nevada	15,000.00	9,986.61	1,977.70	68.82	144.34	189.11	167.83	128.37
New Hampshire	15,000.00	11,126.70	1,239.33	7.54	17.95	.....	420.96	269.39
New Jersey	15,000.00	11,581.70	727.58	34.64	1.00	273.33	542.21	312.53
New Mexico	15,000.00	8,904.23	2,863.21	44.50	82.70	260.24	498.72	533.04
New York (State)[1]	1,500.00	1,499.76	.....	.....	.....	.....	.....	.....
New York (Cornell)	13,500.00	13,500.00	.....	.....	.....	.....	.....	.....
North Carolina	15,000.00	13,949.17	828.77	81.75	.....	105.00	.....	.....
North Dakota	15,000.00	14,106.58	10.00	.....	.....	.....	177.82	.....
Ohio	15,000.00	9,954.10	2,872.95	.....	.....	.....	1,462.82	.....
Oklahoma	15,000.00	11,441.58	1,630.71	16.90	.....	24.43	242.43	309.67
Oregon	15,000.00	15,000.00	.....	.....	.....	.....	.....	.....
Pennsylvania	15,000.00	10,661.67	903.11	126.64	45.43	42.08	1,124.06	160.91
Rhode Island	15,000.00	9,571.31	3,475.62	9.12	8.34	371.65	98.15	170.91
South Carolina	15,000.00	10,731.76	1,414.82	37.18	76.28	253.51	765.02	216.73
South Dakota	15,000.00	9,041.52	2,989.65	18.72	117.09	.....	529.45	363.71
Tennessee	15,000.00	12,794.01	208.20	17.68	64.99	185.41	344.04	35.59
Texas	15,000.00	10,652.60	1,621.54	24.78	112.81	39.42	705.38	365.05
Utah	15,000.00	10,654.34	2,438.82	.....	91.59	130.23	554.58	511.07
Vermont	15,000.00	9,334.16	2,586.76	52.29	29.34	182.42	667.87	355.28
Virginia	15,000.00	9,546.66	3,064.48	12.43	63.38	1.25	37.08	96.04
Washington	15,000.00	11,884.57	1,704.12	7.00	.....	60.75	464.86	5.17
West Virginia	15,000.00	11,767.16	1,303.72	8.00	.....	16.00	210.97	248.01
Wisconsin	15,000.00	8,600.00	3,112.50	3.30	143.55	.....	87.64	441.29
Wyoming	15,000.00	12,839.66	75.00	34.82	22.61	42.12	882.72	32.23
Total	720,000.00	547,649.58	61,154.11	1,566.96	2,881.98	5,549.63	21,744.10	9,919.97

[1] Including a balance of $34.78.

act of March 16, 1906 (Adams Act), for the year ended June 30, 1921.

Classified expenditures.										
Fertilizers.	Feeding stuffs.	Library.	Tools, implements, and machinery.	Furniture and fixtures.	Scientific apparatus.	Live stock.	Traveling expenses.	Contingent expenses.	Buildings and repairs.	Balances.
$35.00	$475.95	$137.53	$317.28	$245.86	$1,093.11	$93.75	$620.45	.....	$4.63	.....
.....	.....	2.87	21.00	.....	78.16	.....	165.40	.....	236.00	.....
217.34	412.62	3.09	599.62	1.25	1,699.83	.....	421.68	.....	6.80	.....
.....	.....	21.06	6.43	.....	54.76	.....	250.61	.....	490.15	.....
.....	24.00	11.36	49.85	16.20	299.53	10.50	344.30	.....	356.41	.....
.....	273.53	.....	24.05	26.21	.....	.....	70.22	$11.50	55.30	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
22.47	.....	20.50	36.61	5.50	1,195.00	.....	132.72	.....	40.71	.....
614.60	.....	67.67	95.72	135.25	534.58	.....	894.64	.....	291.31	.....
.....	1,695.36	64.64	70.77	.....	80.20	1,006.33	47.40	.....	.....	.....
.....	195.75	6.03	453.23	.....	273.13	.....	249.23	.....	64.60	.....
.....	210.18	.....	204.81	.....	112.25	38.50	68.38	.....	.....	.....
18.60	.....	70.71	137.21	6.85	800.06	649.69	391.50	.....	.62	.....
1.00	411.48	.....	38.60	.....	526.00	.....	.....	.....	152.42	.....
.....	1,250.04	2.00	228.04	23.64	84.73	96.50	116.31	1.46	25.31	.....
.....	202.00	.....	.....	.....	.....	160.00	2.16	.....	.....	.....
.....	167.69	326.72	15.97	446.25	1,687.62	.....	454.08	.....	10.17	.....
.....	1,161.35	14.69	3.15	53.00	220.28	114.45	427.61	20.00	79.36	.....
.....	.....	.....	48.09	102.72	348.87	.....	67.43	.....	79.06	.....
142.48	8.45	.....	.....	.....	101.13	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	154.25	76.24	.....	.....	211.55	.....	64.30	.....	.....	.....
.....	3,786.17	.....	153.86	6.60	804.04	24.60	92.62	.....	167.97	.....
.....	.....	29.60	9.50	60.74	692.84	.....	764.31	.....	.....	.....
.....	208.70	.....	370.81	.....	662.24	844.18	160.34	.....	.....	.....
.....	340.48	53.79	73.28	2.50	2.00	1,588.85	276.32	.....	.....	.....
.....	553.86	.....	78.89	28.50	825.17	.....	80.27	.....	351.44	.....
8.87	360.00	88.40	475.71	140.11	38.80	.....	8.94	.....	406.18	.....
33.54	473.11	3.33	334.41	41.92	294.98	350.00	.....	.....	282.07	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	$0.24
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	35.31	.....	.....	.....	.....
.....	.....	.....	.....	.....	89.79	615.71	.....	.....	.....	.....
.....	.....	17.17	32.75	.....	383.31	.....	.....	10.00	266.90	.....
.....	551.66	27.00	197.18	33.00	166.31	115.63	119.40	.....	124.10	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2.00	70.53	191.83	14.39	9.15	1,275.64	.....	155.80	.46	216.30	.....
.....	787.32	9.00	109.20	.....	176.39	80.00	.....	.....	132.99	.....
.....	410.94	7.50	400.92	132.26	436.20	100.00	5.89	.....	10.99	.....
124.03	248.45	16.00	212.65	227.39	689.37	.....	.....	63.33	358.64	.....
.....	.....	67.73	512.03	128.10	226.27	.....	303.71	.....	112.24	.....
.....	132.45	.....	30.91	.....	1,131.50	57.64	.....	.....	125.92	.....
.....	.....	8.00	31.50	.....	340.37	.....	223.85	.....	12.65	.....
3.78	249.59	7.46	8.75	17.75	488.94	425.00	183.51	.....	407.10	.....
206.75	1,405.26	2.75	3.25	.....	367.92	.....	45.16	.....	147.59	.....
3.75	.....	10.00	30.66	.....	465.17	.....	363.95	.....	.....	.....
29.75	452.58	5.50	69.80	68.65	562.68	.....	257.18	.....	.....	.....
.....	1,845.84	.....	91.21	76.69	285.98	312.00	.....	.....	.....	.....
.....	692.96	.....	114.44	.....	94.50	68.90	69.14	.....	30.90	.....
1,463.96	19,212.55	1,370.17	5,709.53	2,036.09	19,901.20	6,787.54	7,898.81	106.75	5,046.83	.24

Disbursements from the United States Treasury to the States and Territories for agricultural experiment stations under the acts of Congress approved March 2, 1887, and March 16, 1906.

State or Territory.	Hatch Act.		Adams Act.	
	1888–1920	1921	1906–1920	1921
Alabama	$493,956.42	$15,000.00	$191,619.89	$15,000.00
Arizona	459,803.10	15,000.00	194,955.61	15,000.00
Arkansas	493,139.12	15,000.00	194,900.00	15,000.00
California	495,000.00	15,000.00	194,926.84	15,000.00
Colorado	494,718.82	15,000.00	193,638.93	15,000.00
Connecticut	495,000.00	15,000.00	195,000.00	15,000.00
Dakota Territory	56,250.00			
Delaware	493,382.87	15,000.00	190,475.12	15,000.00
Florida	494,966.06	15,000.00	194,995.06	15,000.00
Georgia	490,593.43	15,000.00	182,092.87	15,000.00
Idaho	419,324.13	15,000.00	190,842.22	15,000.00
Illinois	494,564.95	15,000.00	194,851.62	15,000.00
Indiana	494,901.19	15,000.00	195,000.00	15,000.00
Iowa	495,000.00	15,000.00	195,000.00	15,000.00
Kansas	494,995.00	15,000.00	195,000.00	15,000.00
Kentucky	494,995.57	15,000.00	195,000.00	15,000.00
Louisiana	495,000.00	15,000.00	195,000.00	15,000.00
Maine	494,999.62	15,000.00	195,000.00	15,000.00
Maryland	494,967.40	15,000.00	194,236.48	15,000.00
Massachusetts	494,617.70	15,000.00	193,000.00	15,000.00
Michigan	494,676.10	15,000.00	191,341.20	15,000.00
Minnesota	494,917.78	15,000.00	194,345.00	15,000.00
Mississippi	495,000.00	15,000.00	195,000.00	15,000.00
Missouri	490,097.24	15,000.00	194,999.90	15,000.00
Montana	405,000.00	15,000.00	192,417.04	15,000.00
Nebraska	494,932.16	15,000.00	195,000.00	15,000.00
Nevada	494,214.32	15,000.00	193,180.18	15,000.00
New Hampshire	495,000.00	15,000.00	195,000.00	15,000.00
New Jersey	494,949.97	15,000.00	194,558.78	14,833.28
New Mexico	459,509.05	15,000.00	195,000.00	15,000.00
New York	494,765.94	14,999.49	194,498.03	14,965.22
North Carolina	495,000.00	15,000.00	180,000.00	15,000.00
North Dakota	436,502.26	15,000.00	194,638.85	15,000.00
Ohio	495,000.00	15,000.00	193,514.02	15,000.00
Oklahoma	419,568.96	15,000.00	176,360,56	15,000.00
Oregon	480,156.64	15,000.00	190,000.00	15,000.00
Pennsylvania	494,967.43	15,000.00	194,995.41	15,000.00
Rhode Island	495,000.00	15,000.00	192,464.20	15,000.00
South Carolina	494,542.15	15,000.00	193,460.12	15,000.00
South Dakota	438,250.00	15,000.00	190,000.00	15,000.00
Tennessee	495,000.00	15,000.00	195,000.00	15,000.00
Texas	495,000.00	15,000.00	192,592.26	15,000.00
Utah	360,000.00	15,000.00	194,821.94	15,000.00
Vermont	495,000.00	15,000.00	195,000.00	15,000.00
Virginia	492,824.12	15,000.00	194,949.01	15,000.00
Washington	432,102 65	15,000.00	191,080.11	15,000.00
West Virginia	494,968.71	15,000.00	192,859.12	15,000.00
Wisconsin	495,000.00	15,000.00	195,000.00	15,000.00
Wyoming	480,000.00	15,000.00	195,000.00	15,000.00
Total	23,142,121.86	719,999.49	9,264,611.47	719,798.50

LIST OF PUBLICATIONS OF THE EXPERIMENT STATIONS DURING THE FISCAL YEAR 1921.

AGRICULTURAL CHEMISTRY—AGROTECHNY.

Concerning Inosite Phosphoric Acids:—I. Synthesis of Phytic Acid.—II. Composition of Inosite Phosphoric Acid of Plants. By R. J. Anderson. (New York State Sta. Tech. Bul. 29, pp. 22.)

Unfermented Fruit Juices. By W. V. Cruess. (California Sta. Circ. 220, pp. 32, figs. 18.)

Apple Candy.—A Commercial Use for Cull Apples. By T. H. Abell. (Utah Sta. Bul. 179, pp. 14, figs. 7.)

Sugar Beet and Apple Sirups. By L. E. Longley. (Idaho Sta. Circ. 14, pp. 7, figs. 4.)

Products and Utilization of Muscadine Grapes. By W. J. Young. (South Carolina Sta. Bul. 206, pp. 37, figs. 5.)

Commercial Production of Grape Sirup. By W. V. Cruess. (California Sta. Bul. 321, pp. 401–416, figs. 5.)
The Evaporation of Grapes. By W. V. Cruess, A. W. Christie, and F. C. H. Flossfeder. (California Sta. Bul. 322, pp. 421–471, figs. 11.)
The Clarification of Cane Juice Without Chemical Treatment. By F. W. Zerban. (Louisiana Stas. Bul. 173, pp. 26, figs. 2.)
The Prevention of Sugar Deterioration. By N. Kopeloff, C. J. Welcome, and L. Kopeloff. (Louisiana Stas. Bul. 175, pp. 58, fig. 1.)
Factors Determining the Keeping Quality of Cane Sugar. By N. and L. Kopeloff. (Louisiana Stas. Bul. 170, pp. 63, fig. 1.)
Paint Bulletin, Food Department. (North Dakota Sta. Paint Bul. 1 (1919), No. 7, pp. 113–138, fig. 1.)

BOTANY.

The Malvaceous Plants of Texas. By H. C. Hanson. (Texas Sta. Circ. 22, pp. 18.)
Normal and Abnormal Germination of Grass Fruits. By J. Zinn. (Maine Sta. Bul. 294, pp. 197–216, pls. 4.)
Sturtevant's Notes on Edible Plants. By U. P Hedrick. (New York State Sta. Rpt. 2 (1919), part II, pp. VII+686, pl. 1.)

GENETICS.

Asexual Inheritance in the Violet (*Viola odorata*). By R. D. Anthony. (New York Sta. Tech. Bul. 76, pp. 55, figs. 12.)
Inbreeding Animals.—I, Experimental Evidence; II, Experimental Results. By F. A. Hays. (Delaware Sta. Bul. 123, pp. 49, figs. 9.)
The Occurrence of Red Calves in Black Breeds of Cattle. By L. J. Cole and S. V. H. Jones. (Wisconsin Sta. Bul. 313, pp. 35, figs. 4.)
A Comparison of Some Traits of Conformation of Southdown and Rambouillet Sheep and of their F_1 Hybrids, with Preliminary Data and Remarks on Variability in F_2. By E. G. Ritzman and C. B. Davenport. (New Hampshire Sta. Tech. Bul. 15, pp. 32, figs. 25.)
Broodiness in Domestic Fowl.—Data Concerning Its Inheritance in the Rhode Island Red Breed. By H. D. Goodale, R. Sanborn, and D. White. (Massachusetts Sta. Bul. 199, pp. 93–116, figs. 4.)
Studies on the Inheritance of Egg Weight.—I, Normal Distribution of Egg Weight. By P. Hadley and D. W. Caldwell. (Rhode Island Sta. Bul. 181, pp. 64, pl. 1, figs. 42.)

METEOROLOGY.

Meteorological Observations at the Massachusetts Agricultural Experiment Station. By J. E. Ostrander and G. E. Lindskog. (Massachusetts Sta. Met. Buls. 378–380, pp. 4 each.)
Meteorological Observations at the Massachusetts Agricultural Experiment Station. By J. E. Ostrander and H. W. Poole. (Massachusetts Sta. Met. Buls. 381–389, pp. 4 each.)
Ohio Weather for 1919. By W. H. Alexander and C. A. Patton. (Ohio Sta. Bul. 345, pp. 481–570, figs. 62.)

SOILS.

Testing Soils for Acidity. By E. Truog. (Wisconsin Sta. Bul. 312, pp. 24, pl. 1, figs. 11.)
Lime Requirement of Pennsylvania Soils. By J. W. White. (Pennsylvania Sta. Bul. 164, pp. 36, figs. 7.)
The Present Status of Alkali. By W. P. Kelley. (California Sta. Circ. 219.)
I. Report on Soil Experiment Fields.—II. Maintenance of Fertility. By G. Roberts and A. E. Ewan. (Kentucky Sta. Bul. 228, pp. 89–131, fig. 1.)
The Illinois System of Permanent Soil Fertility as Developed by Cyril G. Hopkins. By R. Stewart. (Illinois Sta. Circ. 245, pp. 20, figs. 5.)
Soil Fertility. By M. M. McCool, C. E. Miller, and G. M. Grantham. (Michigan Sta. Pop. Bul. 290, pp. 39, figs. 15.)
Soil Fertility Experiments on DeKalb, Volusia, and Westmoreland Soils. By J. W. White and F. J. Holben. (Pennsylvania Sta. Bul. 166, pp. 23, figs. 5.)

Some Observations on Soil Fertility and Crop Production. By W. H. Jordan, G. W. Churchill, and J. D. Luckett. (New York State Sta. Bul. 473, pop. ed., pp. 18, fig. 1.)
Keeping Soils Productive. By R. R. Hudelson. (Missouri Sta. Circ. 102, pp. 24, figs. 8.)
The Relation of the Phosphoric Acid of the Soil to Pot Experiments. By G. S. Fraps. (Texas Sta. Bul. 267, pp. 53, figs. 2.)
The Carbon Dioxid of the Soil Air. By H. W. Turpin. (New York Cornell Sta. Mem. 32, pp. 319–362, 17.)
Some Effects of Potassium Salts on Soils. By R. S. Smith. (New York Cornell Sta. Mem. 35, pp. 565–605, figs. 3.)
Nitrate Production in Field Soils in Illinois. By A. L. Whiting and W. R. Schoonover. (Illinois Sta. Abs, of Bul. 225, pp. 4.)
Nitrification in Acid Soils. By R. E. Stephenson. (Iowa Sta. Res. Bul. 58, pp. 331–349.)
Nitrification in Texas Soils. By G. S. Fraps. (Texas Sta. Bul. 259, pp. 37, figs. 2.)
Nitrogen from the Air. By J. G. Hutton. (South Dakota Sta. Soil Survey Circ. 1, 1920, pp. 4.)
The Fixation of Nitrogen in Colorado Soils.—A Study of the Wellington District, Laramer County, Colorado. By W. P. Headden. (Colorado Sta. Bul. 258, pp. 48, fig. 1.)
The Management of Sandy Soils under Irrigation. By H. K. Dean. (Oregon Sta. Bul. 177, pp. 26, figs. 13.)
Summer Fallowing Experiments in the Judith Basin. By W. P. Baird. (Montana Sta. Bul. 138, pp. 39, figs. 3.)
Soils of the Detroit Area. By M. M. McCool and G. M. Grantham. (Michigan Sta. Spec. Bul. 104, pp. 31, figs. 15, pl. 1.)
Report of Golden Valley Peat Experimental Fields, 1918–19. By F. J. Alway. (Minnesota Sta. Bul. 194, pp. 116, figs. 43.)
Biennial Report Oregon Soil Investigations, 1918–1920. (Oregon Sta. Rpt. 1918–1920, pp. 46, figs. 34.)
The Soils of Northern Wisconsin. By A. R. Whitson, T. J. Dunnewald, and C. Thompson. (Wisconsin Sta. Bul. 306, pp. 45, pls. 5, figs. 3.)
Soil Survey Reports of Iowa. By W. H. Stevenson and P. E. Brown. Iowa Sta. Soil Survey Rpts.—
No. 4, Webster County Soils. pp. 48, figs. 11, maps 2.
No. 5, Lee County Soils. pp. 48, figs. 11, map 1.
No. 6, Sioux County Soils. pp. 48, figs. 16, maps 2.
No. 7, Van Buren County Soils. pp. 52, figs. 18, map 1.
No. 8, Clinton County Soils. pp. 64, figs. 23, maps 2.
No. 9, Scott County Soils. pp. 48, figs. 17, maps 1.
No. 10, Ringgold County Soils. pp. 48, figs. 17. map 1.
No. 11, Mitchell County Soils. pp. 44, figs. 15, map 1.
No. 12, Clay County Soils. pp. 54, figs. 11, map 1.
No. 13, Montgomery County Soils. pp. 46, figs. 10, map 1.
No. 14, Black Hawk County Soils. pp. 60. figs. 12, map 1.
No. 15, Henry County Soils. pp. 60, figs. 15, map 1.
No. 16, Buena Vista County Soils. pp. 54, figs. 12, map 1.
No. 17, Linn County Soils. pp. 60, figs. 11, maps 2.
No. 18, Wapello County Soils. pp. 56, figs. 10, map 1.
The Missouri Soil Survey. By H. H. Krusekopf. (Missouri Sta. Circ. 104, pp. 20, figs. 21.)
Chemical Composition of Some Louisiana Soils as to Series and Texture. By S. S. Walker. (Louisiana Stas. Bul. 177, pp. 27, figs. 4.)
The Chemical Composition of the Soils of the Camden Area in New Jersey. By A. W. Blair and H. C. McLean. (New Jersey Stas. Bul. 346, pp. 40, figs. 2.)

FERTILIZERS.

Testing Fertilizers for Missouri Farmers, 1920. (Missouri Sta. Bul. 178, pp. 72, fig. 1.)
Agricultural Lime. By M. F. Miller and H. H. Krusekopf. Missouri Sta. Bul. 171, pp. 24, figs. 8.)
Sources of Agricultural Liming Materials. By R. C. Collison. (New York State Sta. Bul. 478, pp. 14.)

A Complete Fertilizer for Savannah Cranberry Land. By C. S. Beckwith. (New Jersey Stas. Circ. 124, pp. 4, fig. 1.)

Soil Studies.—I. The Influence of Fertilizers Upon the Productiveness of Several Types of Soil.—II. The Influence of Fertilizers and Plant Growth Upon Soil Solubles. By W. H. Jordan. (New York State Sta. Bul. 473, pp. 27.)

I. Potash Shales of Illinois; II. Geology, Distribution, and Occurrence in Union County; III. Finely-ground Shale as a Source of Potassium for Soil Improvement. By S. W. Parr, M. M. Austin, F. Krey, and R. Stewart. (Illinois Sta. Bul. 232, pp. 227–252, figs. 7.)

Bat Guano and its Fertilizing Value. By W. A. Albrecht. (Missouri Sta. Bul 180, pp. 15, figs. 7.)

Some Observations Upon the Effect of Borax in Fertilizers. By W. J. Morse. (Maine Sta. Bul. 288, pp. 89–120, pls. 2, figs. 10.)

Methods of Applying Manure. By W. P. Brooks. (Massachusetts Sta. Bul. 196, pp. 39–60, pl. 1, fig. 1.)

Some of the Effects of the War Upon Fertilizers. By L. L. Van Slyke. (New York State Sta. Bul. 471, pp. 10.)

Bulletin of Immediate Information [Calling the Attention of Purchasers of Fertilizers to Certain Facts]. (Connecticut State Sta. Bul. of Immediate Inform. No. 14, p. 1.)

FIELD CROPS.

Alfalfa.

Factors that Affect Alfalfa Seed Yields. By P. K. Blinn. (Colorado Sta. Bul. 257, pp. 32, figs. 27.)

Experiences with Alfalfa. By S. C. Damon. (Rhode Island Sta. Bul. 184, pp. 26, figs. 4.)

Soil Moisture Movement in Relation to Growth of Alfalfa. By C. A. Thompson and E. L. Barrows. (New Mexico Sta. Tech. Bul. 123, pp. 38, figs. 18.)

The Irrigation of Alfalfa. By F. S. Harris and D. W. Pittman. (Utah Sta. Bul. 180, pp. 30, figs. 8.)

Corn.

Corn Experiments. By H. B. Brown. (Mississippi Sta. Bul. 197, pp. 20, figs. 3.)

Corn Growing in Michigan. By J. F. Cox and J. R. Duncan. (Michigan Sta. Bul. 289, pp. 46, figs. 38.)

Experiments with Corn at the Holly Springs Branch Experiment Station. By C. T. Ames. (Mississippi Sta. Bul. 189, pp. 8.)

Corn Experiments at the Judith Basin Substation. By W. P. Baird. (Montana Sta. Bul. 132, pp. 24, figs. 10.)

The Regional Adaptation of Corn in Nebraska. By T. A. Kiesselbach and F. D. Keim. (Nebraska Sta. Res. Bul. 19, pp. 64, figs. 13.)

The Selection of Seed Corn in Porto Rico. By H. C. Henricksen. (Porto Rico Sta. Circ. 18, pp. 22, figs. 7.)

Freezing Injury of Seed Corn. By T. A. Kiesselbach and J. A. Ratcliff. (Nebraska Sta. Res. Bul. 16, pp. 96, figs. 16.)

Variety Tests of Corn, Wheat, and Soy Beans. By J. E. Metzger and G. Eppley. (Maryland Sta. Bul. 237, pp. 23, figs. 10.)

Corn Variety Tests, 1913–1920 (Delta Branch Station). By W. E. Ayres. (Mississippi Sta. Bul. 198, pp. 7.)

Corn in Missouri.—I. Corn Varieties and Their Improvement. By L. J. Stadler and C. A. Helm. (Missouri Sta. Bul. 181, pp. 51, figs. 7.)

Variety Tests with Corn, 1917–1920. (South Carolina Sta. Bul. 207, pp. 19.)

Corn Variety Experiments, Substation No. 3, Angleton, Texas. By E. B. Reynolds. (Texas Sta. Bul. 276, pp. 15, figs. 2.)

Comparison of Peanut Meal, Cottonseed Meal, Velvet Bean Meal, Ammonium Sulphate, and Nitrate of Soda as Fertilizers for Corn and Cotton. By E. F. Cauthen. (Alabama Sta. Bul. 215, pp. 8.)

Cotton.

Upland Long Staple Cotton in Arkansas. By E. A. Hodson. (Arkansas Sta. Circ. 49, pp. 4, fig. 1.)

The Staple of Texas Cotton. By E. P. Humbert. (Texas Sta. Bul. 266, pp. 7, fig. 1.)

Cotton—Continued.

Cotton Growing in South Mississippi. By E. B. Ferris. (Mississippi Sta. Bul. 196, pp. 8.)
Cotton Experiments 1919–20. By H. B. Brown and C. B. Anders. (Mississippi Sta. Bul. 187, pp. 31, figs. 4.)
Sea Island Cotton in St. Croix. By L. Smith. (Virgin Islands Sta. Bul. No. 1, pp. 14, pls. 2.)
Results of Seven Years' Pedigree Selection in Trice Cotton. By E. A. Hodson. (Arkansas Sta. Bul. 171, pp. 27, figs. 14.)
Correlations of Certain Characters in Cotton. By E. A. Hodson. (Arkansas Sta. Bul. 169, pp. 15, figs. 3.)
Cotton Varieties. By T. S. Buie. (Georgia Sta. Bul. 136, pp. 15–22.)
Varieties of Cotton 1919 and 1920 and Summary of Ten Years' Results, 1911–1920 (Delta Branch Station). By W. E. Ayers. (Mississippi Sta. Circ. 36, pp. 4, figs. 7.)
Cotton Variety Experiments, Substation No. 3, Angleton, Texas. By E. B. Reynolds. (Texas Sta. Bul. 274, pp. 10.)
Cotton Fertilization Experiments, 1920. By F. H. Smith and T. S. Buie, (Georgia Sta. Bul. 137, pp. 27–36.)
Cultural Experiments with Cotton (Delta Branch Station). By G. B. Walker and W. E. Ayres. (Mississippi Sta. Circ. 35, pp. 4.)
Report of Cotton Experiments at the Holly Springs Branch Experiment Station, Seasons 1919 and 1920. By C. T. Ames. (Mississippi Sta. Bul. 192, pp. 10.)

Forage crops and grasses.

Forage Crops for the Nonirrigated Lands of Idaho. By R. K. Bonnett. (Idaho Sta. Bul. 120, pp. 23, figs. 5.)
Forage Crops in Western Kansas. By R. E. Getty. (Kansas Sta. Bul. 225, pp. 54, figs. 10.)
Lespedeza (Japan Clover). By S. H. Essary. (Tennessee Sta. Bul. 123, pp. 28, figs. 6.)
Hubam Clover. By J. F. Cox, F. A. Spragg, and E. E. Down. (Michigan Sta. Circ. 45, pp. 4, fig. 1.
Water as a Limiting Factor in the Growth of Sweet Clover (*M. alba*). By A. N. Hume, H. Loomis, and J. G. Hutton. (South Dakota Sta. Bul. 191, pp. 255–298, figs. 5.)
Spur Feterita. By A. B. Conner and R. E. Dickson. (Texas Sta. Bul. 275, pp. 28.)
Field Peas for Wisconsin. By E. J. Delwiche. (Wisconsin Sta. Bul. 329, pp. 24, figs. 12.)
Sunflower Production for Silage. By E. G. Schafer and R. O. Westerley. (Washington Sta. Bul. 162, pp. 19, figs. 4.)
Para and Paspalum Grasses. By G. Briggs. (Guam Sta. Circ. 1, pp. 10.)
Profitable Root Crops. By E. J. Delwiche. (Wisconsin Sta. Bul. 330, pp. 22, figs. 12.)

Potatoes.

Potato Improvement by Hill Selection. By G. Stewart. (Utah Sta. Bul. 176, pp. 28, figs. 15.)
Growing Late Potatoes. By J. T. Rosa, jr. (Missouri Sta. Circ. 95, pp. 4.)
Seed Potatoes Improved by Close Planting. By F. C. Stewart and J. D. Luckett. (New York State Sta. Bul. 474, pop. ed., pp. 6.)
Experiments in the Size of the Seed Piece and Other Factors in the Production of Potatoes Under Irrigation in Southern Idaho. By L. C. Aicher. (Idaho Sta. Bul. 121, pp. 15, figs. 8.)
Experiments on the Spacing of Potato Plants. By F. C. Stewart. (New York State Sta. Bul. 474, pp. 32.)
Fertilizers for Potatoes. By W. L. Slate, jr., and B. A. Brown. (Connecticut Storrs Sta. Bul. 106, pp. 39–43.)
Fertilizing the Irish Potato Crop. By B. F. Floyd and R. W. Ruprecht. (Florida Sta. Bul. 158, pp. 28, figs. 2.)
Irrigation of Potatoes. By W. L. Powers and W. W. Johnston. (Oregon Sta. Bul. 173, pp. 28, figs. 9.)
Report of Potato Investigations. By C. F. Clark. (Colorado Sta. Bul. 261, pp. 34, figs. 6.)

Rice.

Rice Investigations. By F. C. Quereau. (Louisiana Stas. Bul. 172, pp. 87, figs. 35.)
The Amount of Salt in Irrigation Water Injurious to Rice. By F. C. Quereau. (Louisiana Stas. Bul. 171, pp. 14, figs. 8.)
Rice Irrigation Measurements and Experiments in Sacramento Valley, 1914–1919. By F. Adams. (California Sta. Bul. 325, pp. 48–69, figs. 4.)

Soy beans.

Soy Beans. By C. R. Megee. (Michigan Sta. Spec. Bul. 100, pp. 11, figs. 5.)
Soy Beans. By C. F. Noll and R. D. Lewis. (Pennsylvania Sta. Bul. 167, pp. 20, figs. 2.)
Field Experiments Which Included the Soy Bean. By B. L. Hartwell. Rhode Island Sta. Bul. 183, pp. 15.)

Sweet potatoes.

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Fruits—General.

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DISEASES OF PLANTS.

Field-crop diseases.

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Field-crop diseases—Continued.

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I. Rusts on Conifers in Pennsylvania.—II. Sexual Fusions and Development of the Sexual Organs in the Peridermiums. By J. F. Adams. (Pennsylvania Sta. Bul. 160, pp. 77, figs. 23.)

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ENTOMOLOGY AND ZOOLOGY.

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Zoology.

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Aids to Successful Oyster Culture.—I, Procuring the Seed. By T. C. Nelson. (New Jersey Stas. Bul. 351, pp. 59, figs. 24.)

FOODS AND HUMAN NUTRITION.

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Economy in Feeding the Family.—Why We Must Have Vegetables. By E. H. Jenkins. (Connecticut State Sta. Bul. of Inform. 11, pp. 3.)

ANIMAL PRODUCTION.

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